CHAPTER 7

A GENERALIZED TRAVEL COST MODEL FOR MEASURING THE RECREATION BENEFITS OF WATER QUALITY IMPROVEMENTS

7.1 INTRODUCTION

While previous chapters have considered "direct" methods of eliciting individuals' valuations of water quality changes, all of which require that individuals be directly asked about their willingness to pay for water quality, this chapter describes an "indirect" method for benefit estimation. This method Uses individuals' actions and a behavioral model that describes individuals' decisions in order to infer water quality values. Specifically, using a generalization of the travel cost model to describe recreation site demand, this approach involves describing the influence of recreation site characteristics, such as water quality, on the demand for a site's services. To accommodate variations in demand for each site's services, the generalized travel cost model uses variations in site attributes across a large number of water-based recreation facilities.

In the process of developing the model, the analysis has attempted to Consider a number of the problems associated with the travel cost framework, including the following:

- The estimation of the opportunity cost of the time spent traveling to a site.
- The treatment of time spent at the site during each trip in relationship to additional trips to the site.
- The specification of the model, including the prospects for biased results from conventional statistical approaches.
- The implications of multiple-purpose trips for the validity of the model.
- The estimation of the specific effects of site attributes on the nature of each site's dem-and function.

This chapter discusses each of these issues in detail. Specifically, Section 7.2 reviews the economic basis for the travel cost model using Becker's [1965] household production framework, and Section 7.3 generalizes the conventional treatment of the travel cost model as a derived demand, assuming site services are inputs to the production of recreation activities. In particular, Section 7.3 considers the problem of modeling site attributes in developing an appropriate quantity index for site services, and it proposes a variant of Saxonhouse's [1977] generalized least-squares estimator to implement the model. Section 7.4 describes the recreation choice and site attribute data used to estimate the travel cost model, and Sections 7.5 and 7.6 present and evaluate results from individual site demand models. In these two sections, as throughout the chapter generally, a major objective is to gauge the implications of modeling decisions for each site demand model used to develop the generalized travel cost model. Section 7.7 presents the generalized travel cost model, and Section 7.8 describes its use to estimate benefits with survey data from users of the recreation sites along the Monongahela River in Pennsylvania. Finally, Section 7.9 presents a brief summary.

7.2 TRAVEL COST MODEL

The travel cost model is widely used to describe demand for recreation facility services (see Dwyer, Kelly, and Bowes [1977] for a review). Indeed, the most recent Water Resources Council [1979] guidelines for benefit-cost analysis call for travel cost methods to estimate the economic value of recreation sites. Although the travel cost model is usually credited to a suggestion made by Harold Hotel ling to the Director of the National Park Service (that distance traveled can indicate the implicit "price" recreationists pay for using a particular facility), Clawson [1959] and Clawson and Knetsch [1966] were the first to develop empirical models based on it. The travel cost model has been refined since this early literature, and it is now recognized as an important indirect methodology for valuing environmental amenities, especially water quality (see Freeman [1979a], Chapter 8, and Feenberg and Mills [1980]).

Of course, recognition of the travel cost model has not come without the parallel development of a behavioral model for the demand patterns it describes. For example, Becker's [1965] household production model can analyze individuals' recreation choices. * While the household production model does not imply new testable hypotheses (see Pollak and Wachter [1975]), it does offer a useful conceptual framework to describe household behavior, especially with respect to outdoor recreation. †

The absence of uniform types of household recreation' data and the lack of organized markets for most recreation site services have compounded the problems of describing consumer demand. Therefore, a framework that can be constructed using the available recreation data has distinct advantages over frameworks that do not. Because these advantages have elsewhere been discussed in detail (see Smith [1975a]; Deyak and Smith [1978]; Cicchetti,

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*In what follows Individual and household are used synonymously. Based on Becker's [1974] work, such conventions do not require models specifying a dictatorial decision process for the household. Rather, households can be seen to act as if guided by a single utility maximizer when altruistic behavior is recognized as an integral component of the social interactions of family members (see Becker [1981] 'for more details).

†It can also provide a basis for consistent welfare measurement. see Bockstael and McConnell [forthcoming].

Fisher and Smith [1976]; and Bockstael and McConnell [1981]), they wil not redeveloped here.

The basic distinction between the household production framework and other approaches stems from its portrayal of the household as both producer and consumer. That is, the household is assumed to consume only services that it produces. For convenience, these services will be designated as final service flows. As with any other production process, these services require inputs. In this case, however, the inputs involve the household's time, as well as market-purchased goods and services. Thus, the framework considers the purchased goods as an indirect means to maximize utility.

The household production framework has two steps or stages, which, though purely logical abstractions, can explain how households make decisions. The first step Involves selecting market goods and services and allocating available household time to minimize the costs of each possible set of final service flows. In the second step, based on the outcomes of the first step, the household defines for itself the "shadow prices, " or marginal costs, of each of the final service flows. Thus, along with the relevant "full" income budget, marginal costs are implied by the selection process for final service flows.

For this study, constrained utility maximization in the household production framework highlights several important aspects of the travel cost model, the first of which is the distinction between the recreation activities undertaken by a household--such as boating, fishing, or swimming--and the usage level of a particular recreation site. To readily identify the implicit price of services of a recreation facility, the former are best treated as measures of household recreation final service flows, and the latter are best treated as an input to the production of such service flows.

Furthermore, the household production framework can readily identify the various ways site services are used. That is, the framework can distinguish whether an individual uses more of a site's services by visiting it a greater number of times during a recreation season or by spending more time at the site during fewer visits. This choice implies a simultaneity problem in modeling household decisions on visits and onsite time per trip. Past efforts have implicitly avoided this problem by assuming that all visits (across all users) are of fixed length (see Cicchetti, Fisher, and Smith [1976]) or by estimating separate models for each trip length (Brown and Mendelsohn [1980]).

Finally, the household production framework permits a general discussion of a household's use of multiple recreation sites that produce identical recreation activities, thus allowing the incorporation of site attributes as determinants of the differences in the demands for the services of multiple sites.

In its simplest form, the household production model can describe recreation decisions by simply distinguishing two types of final service flows produced and consumed by households. The first is the recreation service flow, Z_r, and the second is a nonrecreation service flow, Z_{nr}. Because sets of service flows can be expanded without fundamental changes in the implications of the model, the present analysis has been confined to this simple case. Following earlier developments of the model (see Cicchetti, Fisher, and Smith [1976] as an example), the production function for recreation services can be specified in terms of five inputs: the purchased goods associated with recreation (e. g. , equipment for fishing, boating, camping, etc.), X ; the number of visits to each of two distinct recreation sites, V_1 and V_2; ‘and the time per visit to each site, t_{V_1} and t_{V_2}. It is important to note that this specification greatly simplifies the analysis by maintaining that onsite time per visit is the same for all visits to a given facility.

Equation (7.1) provides a general functional representation of the recreation services production fun”ction:

$$Z_r = f_r(X_r, V_1, V_2, t_{V_1}, t_{V_2}) . \tag{7.1}$$

The time horizon for production activities is often unspecified. However, the household must be assumed to make decisions over” some predefine time horizon that involves a full recreation season (or some fraction) during which multiple visits to different sites are possible.

The production function in Equation (7.1) implicitly maintains that each (Vi, t_{V_1}) pair ideally measures the services provided by each site. Thus, this function effectively skirts a significant index number problem* because differences in the productivity of one site’s services for the recreation service flow are embedded in the function itself. The next section adds further assumptions to this function to investigate the rationale for skirting the index number problem.

Because the focus here is on decisions related to recreation activities, the nonrecreation service flow can be expressed in rather simple terms as related to nonrecreation-re lated purchased goods, $X_{\_}$, and household time spent on the nonrecreation service flow, t_n, as in Equation’’ (7.2):

$$z_{nr} = f_{nr}(X_n, t_n) . \tag{7.2}$$

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*Index number problems are commonplace in the application of micro-economic theory to real-world problems. For example, measures of the quantity of housing pose index number problems because houses are differentiated by number of rooms, floor space, character of external construction (wood frame, brick, etc.), as well as a variety of other features. Because it would not reflect these differences, simply counting the number of houses is insufficient to accurately reflect consumer demand. Similarly, in the case of coffee, multiple end products--ground, instant, “freeze-dried, ” decaffeinated (as weil as combinations of these attributes)- -makes adding pounds of coffee consumed an insufficient way to reflect either how these coffee end products are used or the corresponding features of consumer demand.

In terms of its relationship to practical applications of the travel cost Model, one of the mostimportant aspects of the household production framework arises with the definition of the household's budget constraint. Following Becker's [1965] original suggestions, the household is assumed to face a "full income constraint, Y, including wages, $_{W}t$, nonwage income, R, and foregone income, L. However, it is not assumed that the household necessarily treats the market 'a9e as the opportunity cost of its time in all household production activities. This formulation can be seen as a generalization to that proposed in Cicchetti, Fisher, and Smith [1976]. Equation (7.3) defines this budget Constraint:

$$Y = Wt_w + R + L = P_rX_r + P_nX_n + (T \cdot d_1 + rt_1 + w_1t_{v1})V_1$$

$$+ (T \cdot d_2 + rt_2 + w_2t_{v2})V_2 + Wt_n , \qquad (7.3)$$

where

P_r, P_n = the prices of market-purchased recreation-and nonrecreation - related goods

T = the travel cost per mile

d_i = the roundtrip mileage to the ith site

r = the individual's opportunity cost of traveling time

t_i = time for each roundtrip to the ith site

w_i = the individual's opportunity cost for onsite time at the ith site.

Equation (7.3) identifies three important components of the unit cost of each visit: the travel costs associated with the vehicle used to reach the site, the time costs of the trip, and the opportunity costs of time spent on the site. Only the last of these costs is a choice variable, because the distance and time to reach a recreation facility are defined by the location of that faci l ity in relation to the individual's origin point. Because the model assumes that these locational choices are already determined, their costs are outside the individual's control. *

*Of course, this statement assumes that the individual's opportunity cost of traveling, r, is treated as a fixed parameter to the recreation decision process.

The past literature has devoted considerable attention to the appropriate treatment of the travel and time costs of a trip in the formulation of travel cost demand models. Cesario and Knetsch [1970, 1976] have suggested that the opportunity cost of travel time, r, is less than the wage rate, w, and, in some cases, that travel and time costs may not be additive. The latter component of the Cesario-Knetsch argument has been difficult to substantiate without dropping the assumption that the opportunity cost of travel time is a parameter in the individual's decision process.

For practical purposes, the travel cost literature has tended to focus on the relationship between the cost of travel time, r, and the wage rate, w. Cesario, for example, has suggested that since the cost of travel time involved in urban transportation decisions likely falls between one-fourth and one-half the wage rate (see Cesario [1976], p. 37), one-third might be used as a reasonable approximation for travel cost models. In contrast, McConnell and Strand [1981] have estimated the fraction to be six-tenths for sports fishermen in the Chesapeake Bay region. Their model assumes that the opportunity cost of travel time is a parameter estimated from the data and that travel costs and time costs of travel have equivalent effects on the demand for a site's services. McConnell and Strand caution that this parameter may vary among regions and sites.

The only notable exception to the treatment of r as a multiple of the wage rate arises in Wilman's [1980] recent attempt to compare the Cesario and McConnell approaches for estimating the costs of recreation trips. Wilman's analysis sought to distinguish "scarcity" and "commodity" values for time in modeling the relationship between trips taken and onsite time per trip to produce recreation service flows. * The Wilman model specifies utility as a function of goods and services requiring time, goods and services not requiring time, and two measures of a recreation site's use--the number of visits of a given length to a site and the number of roundtrips to that site. Roundtrips are intended to reflect any satisfaction derived from traveling to the recreation site. By assuming that the time and budget requirements are fixed multiples of the number of visits and roundtrips, Wilman links these choice variables to the household's time and income constraints.

The basis for Wilman's derivation of a different implicit valuation of travel and onsite times is an assumption that the number of trips and visits to a site are equal. The resulting first order conditions require equality between the sum of the marginal utilities of trips and visits and the corresponding goods and time costs of each (weighted by the appropriate Lagrangian multipliers).

Wilman's definition of commodity and scarcity values of time is simply a rearrangement in this allocation condition for visits and trips in an attempt to

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*It should be noted that Wilman did not explicitly adopt a household production framework. However, with relatively minor amendments, her analysis could be cast in these terms.

account for the potential utility derived from travel time. it is important to recognize that the framework maintains that trips and visits are delivered jointly on a one-to-one basis in this version of her model. They must be treated as a single commodity, and any cost allocation between them is arbitrary. Indeed, once the equality assumption between trips and visits is dropped, Wilman's model implies that both types of time should be valued at their scarcity value (see Wilman [1980], Equation [24]). Thus, the existing recreation literature does not provide an unambiguous theoretical justification for distinguishing the valuation assigned to the travel and onsite time components of a recreation experience.

The household. production framework and the procedures used to compile the data for an empirical estimation of travel time costs permit direct investigation of the relationship between the travel time costs and the onsite time costs of the trip. Therefore, the generalized statement of distinct opportunity costs for each time of travel can be accommodated within the empirical model.

To complete the model it is necessary to maintain that the household's utility is a function of the levels of the two final service flows produced as $U(Z_r, Z_{nr})$. Maximizing this utility function subject to the budget and production constraints yields a set of conditions that can be manipulated to suggest that the marginal utility product of each input (i. e., the product of the marginal utility of a service flow times the marginal product of the input in the production of that service flow) relative to its market price, or implicit unit cost, would be equalized over all inputs. More formally, this result is given in Equation (7.4):

$$\frac{MU_{Z_r}\frac{\partial Z_r}{\partial V_1}}{(T\cdot d_1 + r\cdot t_1 + w_1 t_{v_1})} = \frac{MU_{Z_r}\frac{\partial Z_r}{\partial t_{v_1}}}{w_1 V_1} = \frac{MU_{Z_r}\frac{\partial Z_r}{\partial V_2}}{(T\cdot d_2 + r\cdot t_2 + w_2 t_{v_2})}$$

$$= \frac{MU_{Z_r}\frac{\partial Z_r}{\partial t_{v_2}}}{w_2 V_2} = \frac{MU_{Z_r}\frac{\partial Z_r}{\partial X_r}}{P_r} = \frac{MU_{Z_n}\frac{\partial Z_n}{\partial X_n}}{P_n} \tag{7.4}$$

$$= \frac{MU_{Z_n}\frac{\partial Z_n}{\partial t_n}}{w}$$

There are two important aspects of these marginal conditions. First, the assumption that r and w_i are parameters allows all aspects of the costs of an additional visit to each site to be added (i. e., the full cost of a visit to the ith site is $T\cdot d_i + r\cdot t_i + w_i t_v$) and treated as the "price" of that visit. Second, the joint determination' of trips and onsite time implied by this formu -

lation is clearly apparent in the dependency of the unit costs of each of these inputs on the selected levels of the other. *

Solving the necessary conditions of a utility maximum for the optimal number of visits to each site as a function of the parameters in the optimization problem provides the analytical counterpart to the travel cost demand model. These derived demand equations can be written in general form as Equations (7.5) and 7.6):

$$V_1 = L_1(wt_w,\ R,\ L,\ P_r,\ P_n,\ T \cdot d_1 + rt_1,\ T \cdot d_2 + rt_2,\ w_1,\ w_2,\ w), \qquad (7.5)$$

$$V_2 = L_2(wt_w,\ R,\ L,\ P_r,\ P_n,\ T \cdot d_2 + rt_2,\ T \cdot d_1 + \mathrm{roll},\ w_1\ \ w_2,\ w). \qquad (7.6)$$

The relationships in Equations (7.5) and (7.6) are clearly more general than the conventional travel cost demand model. Empirical estimation of these relationships, however, requires several simplifying assumptions. Specifically, full income ($wt_W + R + L$) is assumed to be approximated by family income, and choices of market-purchased recreation and non recreation goods, as well as time used in nonrecreation final service flows, are treated as separable decisions in the consumer's budget allocation process. These assumptions reduce the input demand equations to a format more closely resembling the travel cost specifications. I n the case of the first site, for example, Equation (7.7) would result:

$$V_1 = H_1^*(\tilde{Y},\ T \cdot d_1 + rt_1,\ T \cdot d_2 + rt_2,\ w_1,\ W_2)\ , \qquad (7.7)$$

where

$\tilde{Y}$ = family income as a proxy measure for full income (Y) defined in Equation (7.3).

Before turning to further refinements in this model to accommodate the introduction of specific features of recreation sites as determinants of the variation in the site demand functions, it may be useful to relate the amended travel cost model to some of the existing travel cost studies. (A comprehensive review is available in Dwyer, Kelly, and Bowes [1977].) It is acknowledged at the outset that the features of the existing work can often be explained by inadequacies in the data available on the usage of recreation sites. Indeed, many travel cost studies have been based on aggregate visit patterns rather than on information on the behavior of individual households. These data are typically the result of automobile surveys or the aggregation of user permit information at specific recreational sites. However, information is now available on the number of visitors to a specified site from a set of

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*This framework can also be extended to consider an alternative basis for deriving a relationship between the opportunity cost of travel time and the wage rate by assuming that individuals face different types of time constraints. See Smith, Desvousges, and McGivney [1983] for details.

origin zones (often counties) around the site. With such information, the measure of site usage is generally expressed as a visitor rate (i .e. , number of visits relative to county Population) and is interpreted as an expected "rate of usage" for the "representative" individual in the county. County summary statistics are used as indicators of the economic and demographic characteristics of this "representative" individual. As a consequence, there is often no information with which to estimate the individual's wage rate.

In the presence of these limitations, researchers have taken either of two approaches. The first assumes a constant wage rate for all individuals in all origin zones. The second, somewhat more desirable, uses an estimate based on the wage implied by average family income in the origin zone (i. e., family income divided by an estimate of hours worked per year). Clearly, neither of these options provides a discriminating index of an individual's wage rate. However, the crude nature of the approximations required by the data explain in part Cesario's [1976] willingness to propose a "rule of thumb" for estimating the opportunity cost of travel time.

There are several other problems that arise with travel cost models based on limited data sets. The first of these stems from controlling for trips of different lengths with an aggregate data set. In some cases, researchers have separated data into weekend and weekday visits to ameliorate the problem (see Cicchetti, Fisher, and Smith [19761). An assumption of constant onsite time is otherwise invoked without empirical justification. Equally important, the nature of the trips may be quite different as the distance from the site increases. That is, the trips may have multiple objectives that would imply the full cost of the' trip is not an implicit price for the use of the recreation site but, rather, provides other services as well. *

Recent empirical analyses of the stability of the travel cost model using data aggregated as distance from a site increases suggest it may be possible to detect when violations of these assumptions are severe (see Smith and Kopp [1980]). Of course, this analysis requires the assumptions of constant onsite time across aggregated visits and single-purpose trips, which are more untenable as the distance from the site increases.

The second type of data available for travel cost models involves site-specific user surveys. While these data are in principle superior to the aggregate visit data, incomplete design of the surveys has limited their ultimate usefulness. One especially important omission involves the treatment of usage patterns for recreation facil ities that might be considered substitutes for the one whose users are questioned.

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*Haspel and Johnson [1982] have considered this issue for a survey of users of the Bryce Canyon National Park and found that for this site the assumption of single-purpose trips for visitors was inappropriate. Their findings suggest that 'it would lead to substantial difference< in the estimated travel cost demand functions.

The micro-level data from the surveys, however, have permitted the investigation of a number of issues in modeling recreation demand, including the treatment of: travel costs, the time costs of travel, and the costs of onsite time. Unfortunately, these efforts have not been entirely successful. For example, McConnell and Strand [1981] assume that increases in travel cost and in the time costs of travel should have the same effect on site demand to infer the relationships between the opportunity cost of travel time, r in this study's notation, and the wage rate, w. Their data do not include wage rates that require estimation from family income. The resulting demand equations can exhibit difficulties in estimating precise (i. e., statistically significant) separate estimates of the "price" and income effects on site demand.

The most recent attempt to include both travel cost and the time costs of travel with micro-level data by Allen, Stevens, and Barrett [1981] concludes that it is difficult to distinguish separate effects for these two variables when time is entered without attempting to estimate its opportunity cost (see especially pp. 178-179). The authors suggest collinearity would seem to prevent precise estimation of separate effects of the two variables. Their conclusions contrast with earlier suggestions by Brown and Nawas [1973] and Gum and Martin [1975] that disaggregation would help to resolve these estimation problems.

Theory does imply that travel time should be valued by an opportunity cost. Thus, the Allen, Stevens, and Barrett findings may simply be a reflection of a failure to use all available information from theory. Moreover, the McConnell-Strand empirical results support this optimism.

One important aspect of any attempt to include both travel time and onsite time costs of a trip will be estimation of micro-level wage rates in a way that accurately reflects individual rates of compensation and does not preclude the use of family income as a proxy variable. Such a method is developed in Section 7.4 of this chapter.

The last remaining facet of the idealized travel cost model given in Equation (7.7) involves the treatment of the influence of substitute sites on the demand for any one site's Services. This model explicitly identifies sites that can contribute to the production of the recreation service flow, and it thus requires an approach that treats the effects of other sites. A variety of methods have evolved to incorporate the influence of substitute sites on demand. Because these approaches provide a natural introduction to the extended travel cost model, which allows a site's characteristics to be determinants of intersite demand variation, they are considered as a part of the introduction to the proposed model in Section 7.3.

7.3 THE TRAVEL COST MODEL FOR HETEROGENEOUS RECREATION SITES

As noted in the previous section, the travel cost methodology seeks to model the demand for a recreation site's services. In general, the operational forms of travel cost models focus on estimating site-specific demand functions, and additional sites are considered only to the extent they might provide substitute services for a Particular site under study. Conventional practice has incorporated the role of these substitute services using one of three methods :

- Incorporation of an index of the relative attractiveness and availability of other recreation sites into the relevant site's demand function (see Ravenscraft and Dwyer [1978] and Talhelm [1978]).

- Specification of the recreation demand models to include the prices (i. e., travel costs and time costs of travel) of other substitute recreation sites (see Burt and Brewer [1971] and Cicchetti, Fisher, and Smith [1976]).

- Respecification of the utility function in terms of the attributes of recreation sites so that use patterns are assumed to be in response to utility maximizing selections of these attributes (see Morey [1981]).

Of the three methods, the first is probably the least desirable. It implicitly assumes that an arbitrary index can account for substitute sites in the demand fOr any given recreation site. Of course, the definition of such an attractiveness index . not only requires knowledge of the exact nature of the substitute relationships but also assumes that the index form would be a simple function of the other site's attributes. Thus, this approach requires the very information it is attempting to derive.

The remaining approaches are consistent with economic models of recreation demand. The second approach can be interpreted as an empirical statement of the model given in Equation (7.7), which assumes that the effects of substitute sites on any one site's demand can be captured through the specification that these other sites' "prices" affect the demand for the site of interest. Because the demand for each site is measured individually, the second approach avoids the quantity and price aggregation issues that would impede the consistent definition of the attractiveness index proposed for the first approach.

The last approach addresses the quantity and price aggregation issues directly by assuming a specific format for them in the site attribute specification of the recreationist's utility function. All recreationists are assumed to have the same preferences. This method can be limited by the plausibility of the specification of the utility function.

However, none of these methods offers the ability to consistently relate conventional travel cost site demands to the site features that produce recreation services. That is, while the specification of the household production function for Z_r in terms of several sites implicitly reflects the prospects for substituting one site's services for another's, there. is no direct means for explaining the reasons for the degree of substitution observed between any Pair of sites. This inability to explain the source of, or reasons for, these substitution possibilities is not a limitation for many applications. As noted earlier, when sample information identifies the set of sites considered by individuals as well as their respective patterns of use, cross-price elasticities of demand can be used to estimate measures of the substitution possibilities. Unfortunate y, this information is not uniformly available in all recreation surveys. Indeed, this study's data set, described in the next section, is a survey of users at specific recreation sites, without information on the other recreation facilities respondents may have used or considered using. In such cases, the reasons why substitution prospects exist between recreation sites must be analyzed and some attempt made to reflect them in the modeling of the overall demand for these sites. In simple terms, what is required is the addition of further structure to the household production functions--assumptions that serve to explain why individual site services contribute differentially to the production of recreation service flows and , in turn, why they substitute at different rates.

Before the analysis is formally developed, its implications must be described. This study's approach maintains that each site has a set of characteristics (e.g. , size, water quality, camping facilities, scenic terrain, etc.) and that these attributes contribute to site productivity as inputs to recreation service flow production functions. If the nature of these contributions is restricted to a specific form, originally defined as the simple <u>repackaging hypothesis</u> in problems associated with constructing quality adjusted price and quantity indexes for consumer demand (see Fisher and Shell [1968] and Muellbauer [1974]), the measurement of the role of site characteristics as determina.nts of the features of site demand will provide an explanation of the substitution. As Lau [1982] has demonstrated in another context, the simple repackaging hypothesis implies that site services can be converted into equivalent units based only on their respective characteristics. Thus, after adjustment for their attributes (with Lau's conversion functions), all site services are perfect substitutes for each other. * If this description is plausible, a model of site demand that omits consideration of the role of potential substitute sites will not be biased. Of course, it should be acknowledged that this assumption is a stringent one and that the models developed from it may be limited should the assumption prove to be a poor approximation of processes giving rise to substitution.

To begin the formal development of this model, the original specification of the household production function for recreation service flows (i. e. , Equation [7. 1]) is replaced with one that includes the characteristics of the recreation site, Equation (7. 8):

$$Z_r = f_r(X_r, V_i, t_{v_i}, a_i) , \qquad (7.8)$$

*Berndt [1983] has also recently used this framework to describe the effects of input quality in neoclassical production models.

where

X_r = recreation-related market goods

v_i = number of trips to the ith recreation site

t_{v_i} = time per trip to the ith recreation site (assumed to be constant across all trips)

a_i = vector of attributes for the ith recreation site.

In this form, the relationship between V_i, t_{v_i}, and a_i in the household production function for recreation service flows determines the appropriate index for transforming one site's services into their equivalents for another site. More specifically, given strict monotonicity of the household production function, Equation (7.8) can be solved for V_i.* This resulting function might be designated a site-service requirements function and would be given (in general form) by Equation (7.9):

$$v_i = h(Z_r, X_r, t_{v_i}, a_i) . \tag{7.9}$$

Thus, to convert one site's services into equivalent units of another site, the ratio of the equivalent h(.) functions for each site is needed. ? For example, if there are two sites (designated with subscripts 1 and 2), and if the differences in the production technologies for Z_r using each site can be captured with a_i, the equivalence between trips to each is given by Equation (7.10):

$$V_1 = \frac{h(Z_r, X_r, t_{v_1}, a_1)}{h(Z_r, X_r, t_{v_2}, a_2)} \cdot V_2 . \tag{7.10}$$

This relationship can be further simplified if the ratio V_1/V_2 is assumed to be independent of Z_r, X_r, and t_{v_i} (i = 1,2).‡ Under this assumption, the

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*A monotonic function implies that there is a one-to-one association between the set of independent variables and the dependent variable. In the context of a production function this assumption implies that, if an output Q can be produced with a certain input bundle x, the same output can be produced with more of every input (provided it is possible to costlessly dispose of what is not needed).

†This analysis of the role of site characteristics adapts work recently developed by Lau [1982] for the definition and measurement of a raw materials aggregate within neoclassical models of production.

‡The assumption of independence of t_{v_1} can be easily modified by incorporating it as one of the set of attributes" assumed to be available with each visit to the site. Indeed, this format is equivalent to the assumption made earlier that onsite time is the same for all visits.

site-service requirements function would be given as Equation household production function corresponding to it by Equation (7.12):

$$v_i = \bar{h}(Z_r, X_r, t_{v_i}) \cdot R(a_i) \quad , \tag{7.11}$$

$$Z_r = \bar{f}_r (X_r, t_{v_i}, R(a_i) \cdot V_i) \quad , \tag{7.12}$$

where $R(a_i)$ = the augmentation function.

$R(a_i)$, the augmentation function, provides a specific index that permits each site's services to be transformed into equivalent units. It maintains that this transformation will be constant regardless of the level of the site's services used and will only vary with changes in the attributes (the a_i's) for a site. Consequently, the augmentation function describes how sites would substitute for each other in the production of the recreation service flow, Z_r. This form of the household production function--used in the following discussion--implies that the effects of a site's characteristics on household demands for that site's services can be derived if households can be viewed as engaged in a two-step optimization process to allocate their time and resources. * One of these steps involves minimizing the costs of producing a given output, suggesting that the patterns of trips to recreation sites will be adjusted so the relative unit costs of a trip to any pair of sites would be proportionate to their respective marginal products in contributing to the recreation final service flow. In other words, the effective price of a site's services will be equalized across all recreation facilities considered for use in the production of the recreation service flow.

If the prices of site services are equalized across sites, the augmentation function, $R(a_i)$, provides the means of relating each site's marginal product. Thus, for example, using the augmentation function to compare two sites with different levels of water quality (one with levels permitting recreation fishing and the other permitting only boating), this distinction is captured analytically by a higher augmentation coefficient for the site with cleaner water. Designating the sum of the travel costs and time costs of travel by Pi (i. e., $P_i = T \cdot d_i + r \cdot t_i$) then yields:†

$$\frac{P_1}{R(a_1)} = \frac{P_2}{R(a_2)} \quad , \tag{7.13}$$

or the equivalent of a hedonic price function for sites' services:

$$P_i = g(a_i) \quad . \tag{7.14}$$

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*For further discussion of the application of the household productiot model to modeling outdoor recreation behavior, see Deyak and Smith [1978] and Bockstael and McConnell [1981] .

†This relationship assumes that onsite time is constant and equal for both sites and that the opportunity costs of onsite time are equal for the two sites.

This approach is simply an alternative derivation of the first-stage estimating equation for the Brown-Mendelsohn (1980) hedonic travel cost model. It does not, however, necessarily imply that the marginal prices of attributes will be constant. *

A second implication of the above approach is that the household's cost function for producing Z_r will be a function of the site's attributes. Moreover, the attribute augmentation function, $R(a_i)$, will adjust the effective price of the site's services in the household's cost function, as in Equation (7.15):

$$c = C(Z_r, P_r, W_i, P_i/R(a_i)) \ , \qquad (7.15)$$

where

P_r = price of recreation related commodities

W_i = price of onsite time.

This cost function provides the basis for a generalized travel cost model.

It is assumed that a given recreation site's attributes do not change during a recreation season. Thus, estimates of a travel cost recreation demand for a single site cannot isolate the role of these attributes. Nonetheless, these characteristics should, in principle, affect the form of these demand functions across sites, as seen when Equation (7.15) is differentiated with respect to the site's price, Pi. Following Shephard's [1953] lemma, the partial derivative is the individual's demand for the site's services. Equation (7.16) illustrates that this demand must be a function of the site's characteristics:†

$$V_i^* \cdot \frac{\partial C}{\partial p_i} = \frac{1}{R(a_i)} C_4(Z_r, P_r, W_i, P_i/R(a_i)) \ . \qquad (7.16)$$

To make the framework in Equation (7.16) operational, a number of complications must be considered. The first of these issues involves the recreation service flow, Z_r, for which there is no measure. As a rule, the

*The Brown-Mendelsohn [1980] hedonic travel cost model proposes a two-stage framework. In the first stage, the hedonic price function is estimated for each origin zone by considering the set of recreation sites available to users in that zone, their respective travel and time costs for trips, and their attributes. With these data a separate hedonic price function can, in principle, be estimated for each zone. The partial derivatives of these price functions (which are assumed to be linear in their application) define the implicit prices of the sites' attributes for users in each zone. Using the recreation site choices, their implied levels of attributes, and these implicit prices for attributes, Brown and Mendelssohn then estimate demand functions for each attribute across all origin zones.

†$C_4(\cdot)$ is a short-hand expression for the partial derivative of the cost function $C(\bullet)$, with respect to its fourth argument, $P_i/R(a_i)$.

flows are not part of travel cost demand model s--an exclusion that is justified if the production technology is homothetic and if the levels of production are uncorrelated with other determinants of the demand for a site's services. * That is, the first assumption implies Equation (7.16) can be rewritten as:

$$V_i^* = H(Z_r) \cdot g(p_r,\ w_i,\ P_i/R(a_i),\ R(a_i)) \quad . \tag{7.17}$$

Rewriting Equation (7.17) in logarithmic form yields:

$$\ln V_i^* = \ln\ H(Z_r) + \ln(g(P_r,\ w_i,\ p_i/R(a_i),\ R(a_i))) \ . \tag{7.18}$$

When Z_r is uncorrelated with the arguments of g(.), and when ln(g(.)) is linear in parameters, the ordinary least-squares estimates of these parameters will be unbiased. † Of course, this framework assumes that all individuals produce the same types of activities. ‡

The second complication arises from the treatment of onsite time. The model developed in Section 7.2 described the cost of a site's service by considering the travel and time costs of traveling to the site and the time spent at the site per visit. For simplicity, the time spent onsite was assumed constant for all visits. Thus, the full cost, C_i, of all trips to the ith facility is given as:

$$C_i = (T \cdot d_i + rt_i + w_i t_{v_i})\ V_i \ , \tag{7.19}$$

where

T = travel cost per mile (operating costs for an automobile)

d_i = roundtrip distance in miles

r = opportunity cost of traveling time

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*Any production function that can be written as a monotonic, increasing function of a homogeneous function is a homothetic function. This specification implies that the marginal technical rate of substitution between all pairs of inputs will be constant along rays from the origin. In terms of the cost function corresponding to this production function, the returns to scale (as measured by the elasticity of cost with respect to output) will be a function of the output level.

†To make this judgment, it has been implicitly assumed that the site demand equations include an additive, classically well-behaved error.

‡The framework implicitly assumes that approximately the same mix of recreation activities is undertaken by users. The rationale follows from the assumption that users have comparable household production functions (or that the factors leading to differences in household production technologies can be specified). The assumption on the mix of recreation activities is equivalent to treating Z_r as an aggregate index of all of the recreation undertaken at the site.

t_i = travel time to and from the facility

w_i = opportunity cost of onsite time.

A change of one trip involves a full cost of $T \cdot d_i + rt_i + w_i t_v$. The first two components of these costs are given to each individual once the recreation site is selected. However, this same conclusion does not follow for $w_i t_{v_i}$. The time spent at the site, t_{v_i} is a choice variable. Thus, if onsite cost are included in a travel cost demand model, amending Equation (7.17) to reflect the restriction implicit in the previously described definition of the price of a trip, the estimation of the model must reflect simultaneity in the choice of vi and t_{v_i}. In past studies, this issue has been avoided by assure-ing that Onsite time was constant for all trips. * Section 7.6 evaluates the importance of this simultaneity for the recreation sites in this study.

The measurement of the opportunity cost of travel time, r, and of onsite time, 'i, is also a difficult issue. As noted in the previous section, there has been considerable controversy over the appropriate treatment of the first of these implicit prices. Cesario and Knetsch [1970, 1976] and Cesario [1976] have argued that the wage rate is not an appropriate index of the first of these costs. Rather, based on individual travel choice studies, they have proposed that the opportunity cost of traveling time is a fraction of the wage rate. In this study's sample, the wage rate is estimated based on a wage model derived from the 1978 Current population Survey that permits specific wage predictions to be made for each individual. These predictions take account of the individual's background, including education, age, occupation, sex, race, and other socioeconomic characteristics. As a result, it is possible to separate the estimation of the wage rate from the respondent's reported family income. The next section provides more complete details on the wage model and its predictions for the sample of recreation ists.

Finally, the theoretical model does not offer explicit guidelines as to how a site's attributes affect the derived demand functions for that site's services. The analysis assumes that all of the demand parameters can be affected by a site's features. With the natural log of visits specificied as a function of the travel and time costs of visiting the site, income, and a variety of other determinants, ? using a semilog specification gives the generalized travel cost specification in its simplest form as:

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*This assumption was one of the reasons offered by Smith and Kopp [1980] for a spatial limit to travel cost models estimated from aggregate visit rate information by origin zone.

†Earlier attempts to discriminate between the popular specifications for the travel cost model have not met with great success. Using tests for nonnested models, Smith [1975b] found a slight preference for the semi-log with aggregate visit rate data. Ziemer, Musser, and Hill [1980] have also found support for the semilog specification. However, neither set of results could be regarded as definitive.

$$\ln V_{ij} = \alpha_0(a_{1i}, a_{2i}, \ldots, s_{ki}) + \alpha_1(a_{1i}, a_{2i}, \ldots, s_{ki}) P_{ij} + \alpha_2(a_{1i}, a_{2i}, \ldots, s_{ki}) \tag{7.20}$$

The double subscript for V_{ij} and p_{ij} permits the identification of the site (i) and the individual recreationist (j). ' Thus, V_{ij} is the number of trips to the ith site by the jth individual, P_{ij} is the travel and time costs per trip for the jth individual, and Y_j is that individual's income. Significantly, each parameter of the demand equaiton is specified as a function of the site attributes. Thus, for individuals using the services of a single site, the demand function's parameters are assumed to be constant. Nonetheless, this model has the ability to describe how the demand for a site's services changes with the attributes of that facility. Thus, separate estimates of the demands for individual recreation sites together with measures of their characteristics provide, in principle, the information needed to determine the demand for new sites or for existing sites that experience changes in their available characteristics. These changes might include improvements in water quality, capital additions increasing access points, or improvements to the camping facilities. Thus, this analysis demonstrates that the observed variation in the estimated parameters of travel cost site demand models across sites may be the result of differences in these sites' characteristics. It therefore provides the basis for evaluating the implications of water quality for recreation behavior. Indeed, as suggested in Section 7.7, the estimates of travel cost demand models together with the attributes explaining the variation in the estimated parameters of these models can be used to construct the demand relationships required for a benefits analysis of water quality changes.

It is also important to recognize that the structure of the model provides sufficient information to permit efficient estimation of the role of site attributes for the parameters of site demand. To illustrate this point, consider a general statement of the site demand model:

$$Y_i = X_i\beta_i + \varepsilon_i , \tag{7.21}$$

where

Y_i = N x 1 vector of the measures of the quantity demanded for the ith site's services by each of N individuals

X_i = N x K matrix of demand determinants for the N sampled users of the ith site

β_i = K x 1 parameter vector for the ith site

ε_i = N x 1 vector of stochastic errors for the ith site.

Operationalizing the theoretical specification given in Equation (7.20) is equivalent of assuming that variations in the vector of parameter estimates, β_i, can be explained by the attributes of each recreation site, as in Equation (7.22):

$$\beta_i = \theta A_i, \tag{7.22}$$

where

θ = K x M matrix of parameters describing the effects of site attributes on the parameters of the site demand equations

A_i = M x 1 vector of the M characteristics of the ith site.

The specification for the determinants of site demand parameters will affect the form of the efficient estimator of this two-component model. Under the present specification, a two-step estimation scheme can be considered. The first would involve the estimation of each site demand equation. Assuming there are S sites, the process yields S vectors of estimates for each of the parameters in the β_i vector. Consider the ith such estimate. If ε_i is classitally well behaved, the ordinary least-squares estimate, $\hat{\beta}_i$, of β_i will be unbiased. It can be written as:

$$\hat{\beta}_i = (X_i^T X_i)^{-1} X_i^T Y_i . \tag{7.23}$$

Or, substituting for Y_i from Equation (7.21) yields:

$$\hat{\beta}_i = \beta_i + (X_i^T X_i)^{-1} X_i^T \varepsilon_i . \tag{7.24}$$

Because β_i is not observed, it is necessary to consider the use of estimates in its place. The ordinary least-squares estimate, $\hat{\beta}_i$, is one such possibility. If the model given in Equation (7.21.) has classically well-behaved errors and nonstochastic independent variables as determinants, $\hat{\beta}_i$ is the best linear unbiased estimate of β_i. Substituting for β_i in Equation (7.22) using Equation (7.24) provides the basis for a second-step estimator:

$$\beta_i = \hat{\beta}_i - (X_i^T X_i)^{-1} X_i^T \varepsilon_i = \theta A_i . \tag{7.25}$$

Rearranging terms yields:

$$\hat{\beta}_i = \theta A_i + (X_i^T X_i)^{-1} X_i^T \varepsilon_i . \tag{7.26}$$

Equation (7.26) clearly suggests that, even if $E(\varepsilon_i^2) = \sigma^2$ for all sites (i .e. , i = 1 to s), efficient second-stage estimates require a generalized least-squares estimator. That is, the model given in Equation (7.26) must be estimated taking into account the relative precision of estimation of the $\hat{\beta}_i$

vector across sites. This will be given in each case by the corresponding diagonal elements of Equation (7.27):

$$E(\hat{\beta}_i - \beta_i)(\hat{\beta}_i - \beta_i)^T = \sigma^2(X_i^T X_i)^{-1} . \tag{7.27}$$

The $(X_i^T X_i)^{-1}$ will not be identical across sites, even if the error variances are constant and equal.

Unlike many instances, the nonspherical errors in this framework provide a consistent estimate of the covariance matrix needed for generalized least-squares estimation of the models in terms of $\hat{\beta}_i$. These estimates are contained in the ordinary least-squares estimates of the respective parameter estimates' covariance matrices (i. e., Equation [7.27]).

The generalized travel cost model can be efficiently estimated with a two-step procedure. Each site demand model is estimated with ordinary least-squares (ignoring for the moment any potential simultaneity introduced by the onsite time costs variable). The estimated parameters in these models, together with their estimated variances, provide the basis for the second-step, generalized least-squares estimates of the role of site attributes as determinants of the individual demand parameters. If the jth member of $\hat{\beta}_i$ for i = 1, 2, ... S, if the vector of these estimates is b_j (an S x 1 vector of the ordinary least-squares estimates for the jth parameter in the original β_i vector), and if $\hat{\sigma}_{jj}^2$ is the corresponding diagonal element for $\hat{\sigma}_i^2 (X_i^T X_i)^{-1}$, the generalized least-squares estimator of θ_j (the sth row of θ) is given as follows:

$$\hat{\theta}_j^T = (A^T \hat{\Sigma}^{-1} A)^{-1} A^T \hat{\Sigma}^{-1} b_j , \tag{7.28}$$

where

$$\Sigma = \begin{vmatrix} \hat{\sigma}_{11}^2 & & & 0 \\ & \hat{\sigma}_{22}^2 & & \\ & & \cdot & \\ & & & \cdot \\ 0 & & & \hat{\sigma}_{ss}^2 \end{vmatrix}$$

A = SXM matrix of A_i^S for each of S sites .

This estimator is somewhat different from that described by Saxonhouse [1977] . However, the overall logic is completely parallel. The two generalized least-squares estimators differ in two respects. Saxonhouse [1977] assumes that the first stage models will be jointly estimated with a Zellner [1962] seeming! y unrelated regressions estimator. This approach is more efficient than ordinary least-squares estimates of the individual equations when there is contemporaneous correlation between the stochastic errors across the equations and when the independent variables in all models together are not highly correlated. * As originally formulated, the Zellner estimator maintains that there is an equal number of observations for all models. While Schmidt [1977] has developed variations on the estimator that relaxes this assumption, there is no reason in this application to expect contemporaneous correlation between the errors of the site demand equations. Each will be based on independent surveys of users with little prospect that the same individuals would use more than one site. In the absence of this contemporaneous correlation, there is no advantage to the Zellner estimator. It is identical to the ordinary least-squares estimates for each equation.

The second distinction arises in the specification of the covariance structure for the second step estimates. Saxonhouse's model assumes that Equation (7.22) includes a stochastic error. By maintaining that these errors are independent of the site demand errors, it is possible to develop consistent estimates of the required covariance matrix using the residuals from ordinary least-squares estimates of the second-step models. Saxonhouse's approach can be viewed as a generalized random coefficient model because the parameters of the site demand models are treated as random variables. However, the observed variation in these parameters (across sites) arises from both systematic (i.e. , the differences in each site's characteristics) and random influences. This interpretation has been avoided here in preference for a framework that treats the demand parameters as constants that change with site attributes. Because the true parameters are unobservable, estimates of them must be used to determine the role of these attributes. Thus, random influences enter the framework through the estimates of these parameters and not as an inherent component of the demand model.

I n summary, it has been argued that it is possible to develop a theoretically consistent method for determining the effects of a recreation site's characteristics on the features of the demand for that site's services. Moreover, the framework developed here does not require information on all recreation sites considered by each potential user. This is an important distinction between the approach developed here and the Brown-Mendelsohn [1980] hedonic travel cost model. Equally important, it is possible, using a straightforward, two-step estimation procedure, to provide efficient estimates of the model.

It should be acknowledged that the approach presented here is not new. Freeman [1979a] suggested such a scheme (without explicit consideration of

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*Of course, it is important to recognize that the models discussed here may be biased as a result of the assumption that all sites' services can be transformed into common units using conversion functions in terms of their respective attributes. This framework maintains that, after adjustment for these characteristics, all sites are perfect substitutes in the production of recreation service flows.

the estimation problems) as one of a number of ad hoc approaches to treating water quality effects in modeling the demand for recreation sites. This framework has extented Freeman's suggestion by demonstrating that it is not ad hoc. Rather, it is completely consistent with a household production framework of recreation participation patterns and with the theory of adjusting quantity and price indexes for quality changes in goods and services.

7.4 SOURCES OF DATA

The 1977 Nationwide Outdoor Recreation Survey was conducted by the Heritage Conservation and Recreation Service as part of the Department of Interior's mandate to periodically develop National Recreation Plans. In contrast to past recreation surveys, which only included a general population component, the 1977 survey included general population and site-specific user surveys.

The Federal Estate Survey component of the survey, the primary basis of this study, consists of interviews with recreationists at each of a set of recreation facilities. All federally owned areas with public outdoor recreation were considered to comprise the Federal Estate, and sites were chosen on a basis of specific agency control. The majority of interviews were conducted in areas managed by the National Park Service, the National Forest Service, the U.S. Army Corps of Engineers, and the Fish and Wildlife Service. Each agency was then stratified by Federal Planning Regions, and areas were randomly chosen with weight given to annual visitation in 1975.

Interviewing time at each site was based on visitation, which also determined the number of interviews. The final Federal Estate Survey contains 13,729 interviews over 155 recreation areas. Information collected included socioeconomic characteristics, current outdoor recreation activities, and attitudes toward recreation for each respondent. Data requirements for developing travel cost models that describe demand for individual recreation sites are met by the Federal Estate Survey.

Given that the scope of this study is water-based recreation and that the analysis requires detailed descriptions of the activities at each site, only U.S. Army Corps of Engineer sites were chosen for modeling. These 46 sites also ensured consistent management of recreation activities. Three were eliminated from the analysis because of data inconsistency or ambiguous interview site locations.

A number of the sites selected for analysis from the Federal Estate Survey had observations with incomplete information. Rather than being eliminated from the sample, these observations were classified according to whether or not the missing information affected either the measurements of the use of the relevant recreation sites or the travel and time costs of that use versus the socioeconomic characteristics of the individuals involved. Observations that did not permit evaluation of recreation choices (i.e. , those missing the use and travel information) were eliminated. The remaining incomplete observations were replaced by the mean values of the relevant variables at that site because the demand models were estimated at the site level. This procedure corresponds to the zero-order method for treating missing observations.

Section 7.6 discusses the results of using regression diagnostics to evaluate the sensitivity of each site's estimates to sample composition. In addition to gauging the sensitivity of the estimates to the assumptions of our models, this index also provided a means to evaluate the implications of the procedures used for missing observations.

Several variables in the Federal Estate Survey were reported by discrete internal s.' Answers to questions concerning time spent at site, number of visits to site, travel hours to site, and annual income were treated as continuous variables. In all cases the interval's midpoint was used. Open-ended intervals were converted using the previous interval, with the difference between the previous interval's midpoint and minimum value added to the open-ended minimum value.

One component of the model described in Section 7.3 is the travel cost of a trip, which is defined as the number of miles traveled multiplied by a per mile cost. An independent estimate of travel cost was developed by measuring each respondent's actual road distance traveled to a site based on his reported zip code. All distances were calculated with the Standard Highway Mileage Guide [Rand McNally, 1978] , which lists road miles between 1,100 cities. National interstate highways and primary roads were used in all calculations. Other routes were used only for the distance to the nearest primary road. In cases where cities have multiple zip codes, the center of the city was used as the origin.

The second part of the travel cost calculation requires a per mile cost of a trip. The marginal cost of operating an automobile in 1976 is estimated to be approximatley $0.08 per mile. This estimate is based on costs of repairs and maintenance, tires, gasoline, and oil as reported by the U.S. Census Bureau in the U.S. Statistical Abstract [1978]. Mileage costs for operating an average automobile were then calculated by using the round trip miles to the site multiplied by $0.08. This assumes that the respondent drove directly to the site using the routes in the Standard Highway Mileage Guide. Unfortunately, information was not available on the primary purpose of the respondents' trip or further driving plans.

The Federal Estate Survey includes annual household income of respondents but does not indicate any hourly wage rate. Because the use of reported income in calculating opportunity cost of time precludes determination of income's role in the site demand models, an independent estimate of each individual's wage rate is important to a complete specification of the model .

A hedonic wage model estimated from the 1978 Current Population Survey (CPS) was used to derive these estimates. This model specifies the market clearing wage rates to be a function of individual-, job-, and location-specific characteristics. 'The specific model was developed by Smith [forthcoming, 1983]. By substituting each individual's characteristics" (including location-specific and occupation-specific variables), predicted wage rates were derived. Equation (7.29) provides a general statement of the procedure, with X_{ij} the determinants of the wage rate:

$$\hat{W}_i = \exp\left(\sum_{j=1}^{N} \hat{B}_j X_{ij}\right), \qquad (7.29)$$

where

$\dot{W}_i$ = the predicted wage rate for the ith individual

$\hat{B}_j$ = the estimated coefficient of the jth variable

X_{ij} = the ith individual's value of the jth variable

N = the number of explanatory variables.

Explanatory variables usually include age, sex, education, occupation, and various other job- and location-specific characteristics.

The estimates made in this study should be regarded as proxy measures for actual wage rates. Since the wage model is a semilog, the predictions can be expected to understate the estimated conditional expectation for the wage rate. While Goldberger's [1968] proposed unbiased estimator for this conditional expectation would be superior for large degrees of freedom (the CPS sample contained 9,077 for males and 7,067 for females) and for a small error variance of the estimated model, the bias in this study's estimates will be small. A 10-percent discrepancy would be a generous outer bound on the magnitude of the percentage difference between the direct predictions of these wage rates and the estimates based on Goldberger's method. Indeed, in most large sample applications (see the examples in Goldberger [1968] and Giles [1982]), the actual differences are under 5 percent. Thus, despite this limitation, these estimates provide a better set of proxy measures for wage rates than the available alternatives since they take explicit account of individual and job characteristics. In specifying and estimating the wage model, consideration was also given to measures of job risks, air pollution, climate, crime, access to cultural and sporting activities, and local labor market conditions.

The nominal wage model includes a cost-of-living variable as one of the determinants of wages. Smith used the Bureau of Labor Statistics budget-cost-of-living index for this variable. In the Standard Metropolitan Statistical Areas (SMSAs) where the index was not known, information available for 27 SMSAS was used to model the determinants of variations in the cost of living. As shown in Equation (7.30), the index, C_j, was related to Population density, D_j; the size of the SMSA population in 1975 in thousands, POP_j; and the percent of the population under 125 percent of the poverty standard, $POOR_j$. The t-ratios for the hypothesis of no association are shown in parentheses:

$$c_j = \underset{(37.73)}{111.81} + \underset{(7.38)}{0.005}\, D_j - \underset{(-2.40)}{0.001}\, POP_j - \underset{(-4.36)}{1.30}\, POOR_j$$

$$R^2 = 0.787$$

$$F(3, 23) = 28.34\ . \qquad (7.30)$$

The Federal Estate Survey does not directly identify respondents' SMSA. Thus, a cost of living variable was generated at the State level to minimize computation cost. This index was calculated as the average of the SMSAS within each State, avoiding the need to match each respondent to an SMSA.

The estimated 1977 nominal wages for the recreationists at each site were developed using the equations in Table 7-1. The characteristics necessary for the model were generally available in the Federal Estate Survey, and classifications between the model and the survey were compatible. Problems do arise, however, for respondents who were not labor force participants at the time of the survey. For example, students and housewives could not be considered in the sample used to estimate the hedonic wage model. In these cases, the wages were treated as an opportunity cost estimated to be the mean value by sex of the predicted wage rates in the recreation survey. Table 7-2 provides a summary of predicted hourly wage rates by income and occupation of the respondents. The predicted wage rate is used to calculate the opportunity cost of both onsite time and travel time. For at least two reasons, there are substantial differences in these estimates for the upper income members of the sample. The first stems from the coding of the wage measure in the Current Population Survey. Specifically, the reporting format limits the reported usual weekly earnings (the basis for the hourly wage rate--usual weekly earnings divided by usual hours worked) to $999. Thus, there is censoring in wages for individuals above approximately $52,000 per year. The second reason is that family income can reflect the effects of nonwage income and the impact of dual earner households. Unfortunately, the extent of these influences cannot be sufficiently determined to improve wage rate estimates for individuals in these higher income households.

The U .S. Army Corps of Engineers maintains the Recreation Resource Management System for evaluation and planning. Data from this system are compatible with the sites chosen for the Federal Estate Survey and have been available since 1978. Information is collected annually on each water resource project with 5,000 or more recreation days of use. For 1978, this information included financial statistics, facilities available, natural attributes, recreation participation, and number of employees.

The Recreation Resource Management System is used to define attributes of the 43 Federal Estate Survey sites. Attributes of an area considered include land area, shore miles, pool elevation, the number of multipurpose recreation areas, and facilities provided. Table 7-3 provides descriptive statistics for both the characteristics of the sites and of a selected set of variables for the survey respondents at these sites.

The National Water Data Exchange (NAWDEX) is a membership of water-oriented organizations and is a major source of water quality information. The NAWDEX system is under the direction of the U.S. Geological Survey, and its primary function is to exchange data from various organizations. Major sources of information are usually State agencies, the U.S. Geological Survey, the U.S. Army Corps of Engineers, and the U .S, Environmental

Table 7-1. Hedonic Wage Models

Variable[a]	Male: Coefficient	Male: t-statistics (of no association)	Female: Coefficient	Female: t-statistics (of no association)
Intercept	0.631	8.71	0.179	2.03
Education	0.030	4.01	0.028	2.61
Education squared	0.001	3.4.5	0.001	2.15
Experience	0.031	25.83	0.018	15.91
Experience squared	-0.001	-22.35	-0.0002	-11,83
Race	0.113	8.75	-0.024	-1.73
Veteran	0.035	3.50	---	---
Unemployment	-0.012	-3.51	0.002	0.57
Professional	0.086	2.76	0.563	19.17
Managerial	0.142	4.48	0.521	16.15
Sales	-0.0003	-0.01	0.199	6.30
Clerical	-0.099	-3.01	0.390	15.38
Craftsman	0.015	0.48	0.445	8.68
Operative	-0.149	-4.47	0.235	8.09
Transport equipment	-0.118	-3.35	0.366	5.34
Nonfarm labor	-0.131	-3.87	0.199	3.97
Service worker	-0.251	-7.70	0.166	6.26
Injury rate	0.011	10.40	0.012	7.67
Cancer	0.299	2.93	0.105	0.86
TSP	0.0007	2.31	0.0003	0.97
Household head	0.229	16.75	0.069	6.01
Union member	0.178	17.52	0.191	13.81
OJT x Experience	-0.002	-1.64	-0.001	-0,54
Crime rate	0.000005	1.89	-0.000008	2.39
Percent sunshine	-0.002	-2.31	0.0001	0.12
Dual job holder	-0.042	-1.75	-0.025	-0.81
Know x Cancer	3.77	4.58	5.727	4.24
Log (cost of living index)	0.559	7.22	0.606	6.56
	R^2 ='0.47 degrees of freedom = 9,077 F ratio = 292.92		R^2 = 0.33 degrees of freedom = 7,067 F ratio = 135.52	

SOURCE: Smith [1983].

[a]The variable definitions are as follows:

(1) Education--measured as the years corresponding to the highest grade of school attended (this variable is entered in linear and quadratic terms).

(2) Experience --measured using the conventional proxy of age minus years of education minus SIX (this variable is entered in linear and quadratic terms).

(3) Socioeconomic qualitative variables--dummy variables for race (white = 1), sex (male = 1), veteran status (vetaran = 1 and relevant only for males), member of a union (yes = 1), head of the household (yes = 1), and dual job holder (yes = 1).

(4) Occupational qualitative variables--dummy variables to define the respondents occupation as: professional, managerial, sales, clerical, craftsman, operative, transport equipment operator, nonfarm labor, or service worker.

(5) Cancer-- index of exposure to carcinogens.

(6) TSP--average suspended particulate in 1978.

(7) OJT--on-the-job- training program available.

(8) Know--relative number of workers within an industry covered by collective bargaining with health and safety provisions.

The omitted occupational category was defined to correspond to a composite of those occupations that might lead the estimated hourly wage to understate actual earnings. The omitted occupations were farm laborers and private household workers.

A measure of price uncertainty was constructed to provide soma basis for adjusting the experience measure to reflect the different levels of provision of on-the-job training (OJT) across firms. To evaluate the importance of these effects price uncertainty was measured as the unexplained variation (i. e., $1 - R^2$) for [illegible] trand models fit to monthly wholesale price indexes for each of 14 product categories for each year over the period 1976 through 1978. After evaluating each year's index, 1977 was selected for this analysis. The indexes were assigned to individuals according to their industry of employment in an attempt to [illegible] products as closely as possible. The variable was entered as an interaction term with experience.

Table 7-2. Summary of Predicted Hourly Wage Rates (1977 $)

	Total sample	Male	Female
Overall mean	5.44	6.27	4.34
Number of observations	3,460	1,971	1,489
Mean by annual household income[a]			
Under 5,999	5.08	5.79	4.06
6,000 to 9,999	4.92	5.49	4.10
10,000 to 14,999	5.32	6.01	4.38
15,000 to 24,999	5.72	6.70	4.39
25,000 to 49,999	5.98	7.17	4.65
50,000 or more	5.73	6.53	4.65
Mean by Occupation of respondent			
professional, technical, and kindred workers	7.05	7.89	5.65
Farmers	5.15	5.71	2.75
Managers, officials, and proprietors	7.17	7.74	4.94
Clerical and kindred workers	4.34	5.94	4.10
Sales workers	5.18	6.24	3.29
Craftsmen, foremen, and kindred workers	5.89	6.05	4,31
Operatives and kindred workers	4.97	5.15	3.56
Service workers	4.11	4.71	3.18
Laborers, except farm and mine	4.44	4.74	3.11
Retired widows	5.92	6.27	4.34
Students	5.30	6.27	4.34
Unemployed	5.46	6.27	4.34
Housewives	4.37	6.27	4.34
Other	5.71	6.27	4.34
No occupation given	5.49	6.27	4.34

[a]Total number of observations is 3,282.

[b]Total number of observations is 3,460.

Protection Agency (EPA). All water quality data used in the analysis were retrieved from NAWDEX in a series of steps. Collection of useful water quality data was completed by identifying potential monitoring stations and by then obtaining actual data. Potential monitoring stations were identified by defining the recreation area in terms of latitude and longitude. A general retrieval was then obtained that listed station name, location, parameter Collected, years of data collection, and agency responsible for the data collection.

Table 7-3. The Characteristics of the Sites and the Survey Respondents Selected from the Federal Estate Survey

	Site characteristics				Characteristics of survey respondents										Number of obser-vations[b]
					Predicted wage rate		Household Income		Visits		(T+M) Cost		Miles[a]		
Project name	Property code	Recreation days	Shore miles	Area acres	X̄	σ	X̄	σ	X̄	σ	X̄	σ	X̄	σ	
Allegheny River System, PA	300	-			5.45	1.65	15,667	8,625	2.6	2.5	45.19	28.30	106	57	69
Arkabutia Lake, MS	301	2,011,700	134	52,549	5.23	1.45	13,184	8,974	5.4	2.7	20.04	27.94	45	90	61
Lock & Dam No. 2 (Arkansas River Navigation System), AR	302	343,700	96	32,415	5.24	1.03	10,409	3,991	6.8	2.0	3.04	13.01	55	33	41
Beaver Lake, AR	303	4,882,600	449	40,463	5.59	1.70	18,150	9,946	3.5	3.0	94.55	88.64	266	296	226
Belton Lake, TX	304	2,507,000	136	30,789	5.52	1,51	17,279	11,913	6.0	2.8	33.18	52.35	67	142	53
Benbrook Lake, TX	305	1,978,000	37	11,295	5.00	1.21	19,135	10,065	2.3	1.2	30.23	58.93	73	223	46
Berlin Reservoir, OH	306	1,179,000	70	7,9W	5.44	1.24	16,459	10,161	5.2	2.9	21.15	26.63	40	130	96
Blakely Mt. Dam, Lake Ouachita, AR	307	2,104,300	690	82,373	5.24	1.53	17,144	9,524	4.3	2.8	45.39	49.31	121	139	91
Canton Lake, OK	308	3,416,500	45	19,797	5.09	1.54	17,392	10,553	4.6	3.2	32.30	22.97	95	99	74
Clearwater Lake, MO	309	88s3,000	27	18,715	5.43	1.38	17,943	8,456	4.0	2.7	50.51	42.24	140	192	74
Cordell Hull Dam & Reservoir, TX	310	2,167,900	381	32,822	5.43	1.58	15,491	9,215	5.7	2.9	29.65	34.70	60	87	104
DeGray Lake, AR	311	1,659,700	207	31,800	5.17	1.58	19,235	10,612	4.8	2.7	42.04	43.42	115	164	49
Dewey Lake, KY	312	1,116,800	52	13,602	5.83	2.10	18,021	9,559	2.4	2.0	90.75	122.44	243	519	46
Fort Randall, Lake Francis Case, SD	313	4,756,000	540	133,047	5.43	1.69	20,696	11,705	3.3	3.1	100.29	93.59	260	295	50
Grapevine Lake, TX	314	5,139,100	60	17,828	5.20	1.58	19,309	10,992	6.3	2.6	38.45	64.32	92	217	92
Greers Ferry Lake, AR	31s	4,407,000	276	45,548	5.15	1.45	15,890	8,562	4.7	3.0	54.16	70.00	154	306	217
Grenada Lake, MS	316	2,553,800	148	86,826	5.13	1.56	9,199	4,833	6.4	2.6	24.57	32.90	65	165	75
Herds Creek Lake, TX	317	359,500	11	3,027	5.26	1.42	16,263	9,699	4.4	3.0	39.46	48.25	108	170	54
Isabella Lake, CA	318	1,489,200	38	15,977	5.64	1.48	15,938	11,445	3.3	2.5	55.59	45.54	127	100	48
Lake Okeechobee and Waterway, FL	319	2,894,584	402	451,000	5.38	1.20	13,849	9,541	4.1	3.0	24.91	11.03	76	258	30
Lake Washington Ship Canal, WA	320	712,900	80	169	6.26	2.07	16,686	5,815	3.3	3.0	98.63	130.14	338	605	37
Leech Lake, MN	321	950,600	316	162,100	5.90	1.40	18,886	10,986	2.5	1.8	104.08	84.35	268	313	48
Melvern Lake, KS	322	2,034,600	101	24,543	5.69	1.65	18,087	9,015	4.3	3.0	31.48	29.39	84	137	45
Millwood Lake, AR	323	2,042,300	65	142,100	5.49	1.87	18,630	1,319	5.6	3.0	37.62	55.21	90	176	53
Mississippi River Pool No. 3, MN	324	1,323,700	37	20,350	6.36	2.23	29,571	10,895	3.0	2.4	99.20	79.14	196	288	49
Mississippi River Pool No. 6, MN	32S	645,500	55	11,292	5.79	1.42	19,589	10,693	4.8	3.0	52.23	55.19	141	240	70
Navarro Mills Lake, TX	327	1,111,500	38	14,286	5.16	1.41	13,739	4,652	4.6	2.8	27.68	30.29	61	70	42
New Hogan Lake, CA	328	335,200	44	6,162	5.57	1.28	18,954	11,270	4.0	3.1	34.10	14.55	72	29	41
New Savannah Bluff Lock & Dam, GA	329	207,600	32	2,030	5.28	1.13	12,609	9,414	5.8	2.7	18.65	23.78	37	77	39
Norfork Lake, AR	330	3,066,500	380	54,193	5.65	1.61	17,667	8,889	3.2	2.5	94.89	59.65	268	75	42
Ozark Lake, AR	331	1,102,000	173	39,251	5.02	1.22	12,654	7,568	4.9	3.0	58.71	98.54	199	433	52
Perry Lake, KS	332	3,388,000	160	41,769	5.52	1.48	16,565	6,925	4.7	2.7	28.79	24.02	79	109	28
Philpott Lake, VA	333	1,454,800	100	9,600	5.33	1.55	14,268	6,668	5.8	2.6	26.09	46.00	47	100	38
Pine River, MN	334	1,615,100	119	22,177	5.95	1.80	20,097	9,370	2.1	1.4	69.80	50.54	178	188	75
Pokegama Lake, MN	335	948,300	53	66, S42	5.70	1.46	16,816	9,476	3.3	2.7	100.63	122.30	376	590	68
Pomona Lake, KS	336	1,460,400	52	12,301	5.42	1.36	17,265	7,330	5.4	2.8	25.38	23.33	65	115	31
Proctor Lake, TX	337	975,200	27	15,956	5.49	1.63	17,510	11,167	5.4	2.9	46.08	40.96	109	103	52
Rathbun Reservoir, TX	338	2,332,200	156	36,072	5.74	1.56	20,543	7,473	4.3	2.9	41.78	29.18	96	41	31
Sam Rayburn Dam & Reservoir, TX	339	2,728,700	560	176,869	5.32	1.35	19,515	11,331	4.1	2.7	40.23	31.90	85	74	67
Sardia Lake, MS	340	2,488,900	110	98,590	5.41	1,31	13,141	7,223	6.5	2.3	36.08	42.17	123	234	205
Waco Lake, TX	343	3,371,600	60	21,342	5.46	1.25	16,396	12,454	6.9	2.2	33.02	45.10	99	263	61
Whitney Lake, TX	344	1,976,400	170	53,230	5 25	1.29	18,688	11,651	5.0	2.8	35.40	38.03	96	195	201
Youghogheny River Lake ● A	345	1.122,600	38	4,035	5.56	1.59	16,682	11,051	5 4	2.9	24.67	9.48	47	58	31

[a] One-way distance to the site

[b] Number of observations ● .- based on the final models estimated for site.

NOTES: X̄ is the arithmetic mean.
σ is the standard deviation.
(T+M) cost is the sum of vehicle and time-related costs of a

One major problem in the data collection process is the identification of appropriate monitoring sites. Ideally, monitoring stations should be located in the area where recreation occurs. Monitoring sites could only be identified by obscure station names. Furthermore, information is not available according to area names used by survey respondents. Proximity of a water quality monitor to actual recreation could not be determined.

Monitoring sites that could be identified as relevant were then chosen, and the actual water quality data were obtained through NAWDEX. Several problems are inherent in this type of data collection. A brief discussion of the data collection process and some problems encountered follow. The reader is referred to Appendix E for a more detailed discussion of water quality.

Water quality parameters were selected on a basis of previous use and availability among sites. The parameters collected are temperature, PH , dissolved oxygen, biological oxygen demand, turbidity, nitrates, phosphates, fecal coliform, dissolved solids, flow, and Secchi-disk transparency. Of the 43 sites, 16 had no data due to a lack of known monitoring sites.

Actual water quality data were collected for 27 sites for the years 1972 to 1981. Most of these sites were missing information for the year the survey was completed. As a result, calculations were carried out using 1972 to 1981 data. Monthly means for each site were calculated for June through September. An overall mean was also calculated using the four monthly means. In cases where sites were completely missing a parameter, the mean for all sites was used.

individual parameters and indexes are used in the analysis, including both monthly values and a summer average. Index methods include the National Sanitation Foundation and the Resources for the Future measures. Linear combinations of parameters were also tested, although the degree of correlation between parameters was regarded with caution.

The treatment of missing values for these variables led to a lack of variation between sites. This is caused by two factors. First, the averaging of several years distorts the actual water quality for a particular year. Consideration is not given to improvements or deterioration of water quality. Secondly, replacing missing observations with the means smooths out the variation between sites. Any predictions of water quality benefits with the travel cost model will become more reliable as missing observations are replaced with actual data.

The choice of parameters to be measured at a monitoring site varies according to a water body's local characteristics and the agency collecting the sample. This inconsistency in data collection may cause problems when the 43 Army Corps of Engineers' areas are compared. For example, if suspended solids are not considered a problem in an area, they are not likely to be measured. Consequently, several parameters were not available in all areas or during the appropriate time.

In summary, three generally compatible data sources were used. Data obtained from each source are consistent y defined across sites.

7.5 EMPIRICAL RESULTS FOR SITE-SPECIFIC TRAVEL COST MODELS

The theoretical model of the consumer's recreation decisions identified three aspects of the process that may influence the use of the travel cost model for an analysis of the benefits (or costs) of a change in the attributes of a recreation site. Two of these aspects arise in defining the relevant measure of site usage and the associated cost to the individual for a "unit" of the site's services (assuming an ideal quantity index could be derived). In the formal model of household choice, the individual was able to produce additional units of the recreation service flow with more trips of a given length or by increasing the time spent onsite during a fixed number of trips. The household production framework did not specify these choices as perfect substitutes, but it did admit the possibility of substitution. This type of input substitution is plausible because the time horizon for production has been interpreted to be the recreation season. This specification of the problem implies that the number of visits to a given site and the times spent onsite per visit will be jointly determined variables. Indeed, the demand model for visits (i .e. , Equation [7.7]) was expressed as a reduced form equation. Of course, the specific analytical model simplified the issues involved by assuming the time spent onsite was the same for all the visits in a given season. Actual behavior is more complex, with the prospects for different amounts of time spent onsite for every visit. There are several aspects of this problem described below in greater detail. The discussion portrays the treatment of each issue in this analysis and how this treatment compares with earlier literature.

The second aspect of modeling an individual's recreation choices arises in the definition of the cost of a visit to a given recreation site. The analytical model indicated that this cost would be composed of the costs of transportation to the site (i.e. , the product of roundtrip mileage and a vehicle operating cost per mile) and the opportunity costs associated with the time spent traveling to the facility. As noted earlier, the appropriate definition of these opportunity costs has been addressed in several papers in the past literature. The model identifies the cost as r and does not attempt to relate it to the individual's wage rate. Of course, in practice r is unknown and requires estimation. Since the treatment of this variable has important implications for the estimated costs of a trip, the issues involved in this study's modeling choices are detailed below.

Finally, the third aspect of the representation of recreation decisions stems from this chapter's overall objective, which is to evaluate the influence of site characteristics on the demand for the services of a recreation facility. As developed in Section 7.3, some analytical restrictions on the role of site attributes for the production of recreation service flows, together with a diversity of these features across sites, provide sufficient information to estimate the relationship between each site's demand model and its attributes. To estimate this relationship, however, requires the adoption of a common demand specification for all the individual site demand equations. While the sample sites provide the ability to engage in an approximately comparable set of recreation activities, this is not a sufficient reason, in itself, for expecting the site demand models to be comparable. Thus, before turning to the generalized least-squares models for explaining the variation in an individual site's estimated demand parameters, the implications of using a common specification must also be considered. To adequately treat these three issues, a fairly detailed set of statistical analyses of site demand models was undertaken.

The explanation of these results will be developed in this and the next two sections of this chapter. This exposition begins with a more detailed discussion of the conceptual dimensions of each of these issues in the first three subsections of this section. The ordinary least-squares estimates for the general model applied to all 43 sites follow that discussion. The remainder of this section discusses the implications of using conventional pretesting criteria for selecting individual specifications for each site demand, as well as the influence of different approaches for treating the opportunity cost of travel time to each site. Section 7.6 discusses the results of the analysis of onsite time and visits within a simultaneous equation model and the several specific statistical issues that arise for travel cost models because of the nature of the available measures of site usage. The final component of the model is developed in Section 7.7, where the results of the generalized least-squares model for the determinants of the features of recreational site demand equations are presented.

7.5.1 The Treatment of Onsite Time

Ideally, the measurement of site demand models would involve both the number of trips to a particular site and the time spent onsite for each trip. Unfortunately, in practice this information is rarely available.* The source of data for this analysis (the Federal Estate Survey) includes information on the amount of time spent at the site during the trip in which the respondent was interviewed and not the corresponding information for all trips taken during the season. Thus, any attempt to deal with the relationship between onsite time and visits will require further assumptions.

There have generally been two treatments of onsite time in the recreation demand literature. The first of these corresponds to the most common practice in the literature--onsite time is assumed to be constant across trips and across individuals. In this case, the number of visits is a consistent index of the use of a site's services. With this approach, the onsite time (or cost) term is dropped from the travel cost model (and thus the wage rate would not enter Equation [7.7]).†

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*Brown and Mendelssohn [1980] is one notable exception.

†This practice is, strictly speaking, not correct. Even though onsite time is constant and not considered a choice variable, it does influence the cost of a trip (see Equation [7.4]). Moreover, it cannot be treated as a constant displacement to the demand model's intercept because the opportunity costs of time can be expected to vary across individuals.

We considered a role for onsite time under the assumptions that adjustment for simultaneity was unnecessary and that the results were uniformly unsatisfactory. Without an explicit recognition of the simultaneity between Visits and onsite time costs, ordinary least-squares estimates of the role of onsite time costs would lead to the conclusion that these costs were unimportant influences on the demand for each site's services.

The second approach specifies the travel cost demand function for each site to include the costs of onsite time for the trip in which the individual was interviewed. This case implicitly assumes that the time spent onsite is constant for all trips but may well be different across individuals. Thus, the empirical model corresponds to the theoretical structure developed at the outset of this chapter. The first approach corresponds to the basic model and is reported in this section. The second approach is used to gauge the implications of ignoring onsite costs. These results are summarized in Section 7.6.

7.5.2 The Opportunity Cost of Travel Time

As noted earlier, it has often been argued that the opportunity cost of travel time is less than the wage rate. If this cost is known, theory suggests that travel costs and the cost of travel time have equivalent effects on the demand for the site's services (i.e. , their parameters in a linear demand model would be equal). In the absence of information on these opportunity costs , and if it is possible to assume they are a constant fraction of every individual's wage rate, separate effects can be identified for travel cost and the cost of travel time. The relationship between the estimated parameters provides one basis for estimating the constant--essentially the McConnell-Strand [1981] approach. Of course, to apply this approach, independent estimates of roundtrip distance to the site and travel time must be available. Since few travel cost studies have had access to this type of information, many studies accept Cesario's [1976] suggestion that the opportunity cost of travel time is a multiple of the wage rate ranging from one-fourth to one-half and use it in calculating the cost of a trip. In these cases, travel costs and travel time are both based on roundtrip distance. Of course, the latter also requires an assumed velocity of travel, a wage rate, and the Cesario constant to estimate the opportunity cost of travel time.

Since the Federal Estate Survey reports travel time and the Zip codes of each respondent's residential location, it was possible to develop independent estimates of both components of the cost of a trip. Thus, tests for each model evaluate the appropriate treatment of travel costs and the costs of travel time. These tests simply translate the economic Issues and ad hoc practices into restrictions on the parameters of the site demand models.

7.5.3 Results for the Basic Model

Table 7-4 provides the ordinary least-squares estimates for the semilog specification of our travel cost demand models. The general form for the model is given in Equation (7.31) below:

$$\ln(V_i) = \alpha_0 + \alpha_1(TC_i+MC_i) + a_3 INC_i + \varepsilon_i , \qquad (7.31)$$

where

V_i = number of visits during the recreation season for the ith respondent

Table 7-4. Regression Results of General Model, by Site

$$\text{LN VISITS} = \alpha_0 + \alpha_1\,(\text{T+M})\ \text{COSTS}^{a} + \alpha_3\ \text{INCOME}^{b}$$

Site	Site number	Intercept	T + M cost	Income	R^2	DF	F-ratio
Allegheny River System, PA	300	0.53 (2.04)	-0.0005 (-0.13)	8.2×10^{-6} (0.74)	0.01	66	0.29
Arkabutla Lake, MS	301	1.58 (9.99)	-0.0093 (-3.09)	6.2×10^{-6} (0.67)	0.15	58	4.93
Lock and Dam No. 2 (Arkansas River Navigation System), AR	302	2.31 (9.76)	-0.0125 (-2.30)	-1.8×10^{-5} (-1.08)	0.14	38	3.11
Beaver Lake, AR	303	1.61 (16.07)	-0.0066 (-12.77)	-3.5×10^{-6} (-0.78	0.43	224	86.07
Belton Lake, TX	304	1.69 (9.38)	-0.0052 (-2.47)	2.6×10^{-6} (0.29)	0.12	50	3.39
Benbrook Lake, TX	305	1.83 (10.70)	-0.0054 (-4.11)	6.0×10^{6} (0.80)	0.30	43	9.11
Berlin Reservoir, OH	306	1.40 (8.47)	0.0014 (0.43)	-4.1×10^{-7} (-0.05	0.01	93	0.09
Blakely Mt. Dam, Lake Ouachita, AR	307	1.70 (10.08)	-0.0079 (-5.14)	-7.6×10^{6} (-0.98)	0.24	88	13.67
Canton Lake, OK	308	1.77 (8.61)	-0.0206 (-5.28)	7.1×10^{-6} (0.86)	0.28	71	13.98
Clearwater Lake, MO	309	1.51 (5.97)	-0.0032 (-1.42)	-1.0×10^{-5} (-1.21)	0.04	71	1.61
Cordell Hull Dam and Reservoir, TN	310	1.86 (14.13)	-0.0139 (-6.00)	-1.2×10^{-8} (-0.01)	0.34	101	25.57
DeGray Lake, AR	311	1.79 (7.71)	-0.0070 (-3.00)	-6.9×10^{-5} (-0.73)	0.17	46	4.68
Dewey Lake, KY	312	0.42 (2.27)	-0.0024 (-2.95)	2.0×10^{-5} (2.02)	0.18	43	4.72
Ft. Randall, Lake Francis Case, SD	313	1.32 (6.00)	-0.0066 (-5.93)	7.5×10^{-6} (0.91)	0.43	47	17.61
Grapevine Lake, TX	314	1.80 (16.12)	-0.0073 (-8.80)	8.5×10^{-6} (1.70)	0.47	89	39.12
Greers Ferry Lake, AR	315	1.48 (14.08)	-0.0065 (-9.02)	8.4×10^{-6} (1.42)	0.28	214	40.79
Grenada Lake, MS	316	2.04 (12.61)	-0.0095 (-4.36)	-1.0×10^{-5} (-0.68)	0.22	73	10.02
Herds Creek Lake, TX	317	1.73 (8.22)	-0.0050 (-2.11)	-2.1×10^{-5} (-1.76)	0.19	51	5.95
Isabella Lake, CA	318	1.26 (5.55)	-0.0073 (-3.15)	7.9×10^{-6} (0.81)	0.20	45	5.47
Lake Okeechobee and Waterway, FL	319	1.68 (3.68)	-0.0268 (-1.72)	1.9×10^{-7} (0.01)	0.10	27	1.56
Lake Washington Ship Canal, WA	320	0.96 (2.69)	-0.0037 (-3.79)	1.7×10^{-5} (0.84)	0.26	41	7.18

DF = Degrees of freedom.

(continued)

[a] T+M represents the respondents' round trip cost. It is composed of travel time cost (TCOST) and a constant per mile cost of operating an automobile (MCOST).

[b] t-values of no association are shown in parentheses.

Table 7-4. (continued)

Site	Site number	Intercept	T + M cost	Income	R^2	DF	F-ratio
Leech Lake, MN	321	0.87 (3.88)	-0.0022 (-1.83)	3.5×10^{-6} (0.37)	0.07	45	1.68
Melvern Lake, KS	322	1.30 (4.47)	-0.0079 (-1.66)	4.1×10^{-6} (0.32)	0.06	42	1.37
Millwood Lake, AR	323	1.43 (7.94)	-0.0081 (-3.99)	1.8×10^{-5} (2.14)	0.25	50	8.26
Mississippi River Pml No. 3, MN	324	1.33 (4.20)	-0.0057 (-4.62)	4.7×10^{-6} (0.54)	0.34	46	11.67
Mississippi River Pool No. 6, MN	325	1.41 (7.45)	-0.0074 (-4.39)	1.3×10^{-5} (1.53)	0.22	68	9.68
Navarro Mills Lake, TX	327	1.66 (6.40)	-0.0057 (-1.39)	-1.4×10^{-5} (-1.14)	0.06	39	1.33
New Hogan Lake, CA	328	1.04 (2.58)	-0.0040 (-0.41)	7.1×10^{-6} (0.60)	0.01	38	0.23
New Savannah Bluff Lock & Dam, GA	329	1.88 (8.39)	-0.0067 (-1.44)	-9.8×10^{-6} (-0.70)	0.06	36	1.25
Norfork Lake, AR	330	1.13 (4.27)	-0.0047 (-2.55)	9.3×10^{-5} (0.79)	0.14	39	3.30
Ozark Lake, AR	331	1.66 (8.52)	-0.0046 (-4.44)	-8.8×10^{-6} (-0.66)	0.31	49	11.18
Perry Lake, KS	332	1.50 (4.17)	-0.0042 (-0.74)	-1.0×10^{-5} (-0.68)	0.03	25	0.41
Philpott Lake, VA	333	1.90 (9.28)	-0.0087 (-4.40)	-1.7×10^{-6} (-0.13)	0.36	35	10.03
Pine River, MN	334	0.81 (4.65)	-0.0017 (-1.27)	-6.4×10^{-6} (-0.91)	0.04	72	1.39
Pokegama Lake, MN	335	1.44 (7.28)	-0.0033 (-4.46)	-1.4×10^{-5} (-1.57)	0.24	67	10.36
Pomona Lake, KS	336	1.54 (5.35)	-0.0058 (-1.11)	8.4×10^{-6} (0.62)	0,13	28	1.35
Proctor Lake, TX	337	2.06 (13.61)	-0.0134 (-7.50)	1.2×10^{-6} (0.19)	0.54	49	28.39
Rathbun Reservoir, TX	338	0.77 (1.85)	-0.0015 (-0.27)	1.4×10^{-5} (0.82)	0.02	28	0.34
Sam Rayburn Dam & Reservoir, TX	339	1.46 (7.06)	-0.0094 (-2.83)	1.0×10^{-6} (0.13)	0.11	64	4.10
Sardis Lake, MS	340	1.81 (20.73)	-0.0030 (-3.17)	4.3×10^{-6} (0.78)	0.05	202	5.22
Waco Lake, TX	343	1.95 (15.04)	-0.0006 (-0.32)	-7.4×10^{-6} (-1.25)	0.03	58	0.93
Whitney Lake, TX	344	1.41 (13.07)	-0.0025 (-1.80)	3.2×10^{-6} (0.72)	0.02	201	1.80
Youghiogheny River Lake, PA	345	0.29 (0.60)	0.0263 (1.61)	1.7×10^{-5} (1.55)	0.14	28	2.35

DF = Degrees of freedom.

[a] T+M represents the respondents' round trip cost. It is composed of travel time cost (TCOST) and a constant per mile cost of operating an automobile (MCOST).

[b] t-values of no association are shown in parentheses.

TC_i = time costs of travel for the ith respondent, defined as product of the estimated wage rate for the person (see Section 7.6) and the roundtrip travel time

MC_i = travel costs for the ith respondent

INC_i = family income for the ith respondent

ε_i = stochastic error for ith respondent.

Several alternative functional forms were considered. However, the results uniformly favored the semilog form based on the ability to precisely estimate the site demand parameters. Moreover, this specification is generally selected in evaluations of functional forms for the travel cost model (see Smith [1975a], Smith and KOPP [1980], and Ziemer, Musser, and Hill [1980]).

In general the implicit price (TC+MC) of a trip to the site is statistically significant and correctly signed. There is a fairly large range for values for the estimated parameters for the implicit price--ranging from -0.0005 to -0.0139. Only one site exhibited a positive coefficient for the implicit price, and in this case the coefficient would not be judged to be significantly different from zero. In the balance of the models, 27 sites had coefficient estimates that would lead to the judgment of a demand effect significantly different from zero at least at the 5-percent level. The balance of the estimated price coefficients is negative and in many cases is also statistically different from zero at a higher significance level --i.e., 10 percent.

The effect of income is poorly measured in all of these models. In most cases the parameter estimates would lead to the conclusion that income is not a significant determinant of the demands for these sites. Indeed, in a number of the models the estimated parameters were negative. However, these estimated parameters would lead to the conclusion that income's effect was not significantly different from zero.

At first, the lack of significance of income may seem surprising. However, when it is considered in comparison to other recreation applications of the travel cost framework, it is more plausible. For the most part these sites provide high-density camping, swimming, boating, etc. These are activities where the participation decision and level of use decisions were either somewhat insensitive to family income or where income's marginal effect increased and then decreased with increases in the level of income. Table 7-5 summarizes the role of income in the Cicchetti, Seneca, and Davidson [1969] analysis of recreation participation decisions. Of course, it should be acknowledged that these participation models are reduced form equations reflecting the influence of both demand and supply influences (see Smith [1975a] and Deyak and Smith [1978] for further discussion of these approaches). Nonetheless, they provide some information based on the likely implications of the mix of activities a site can support for the nature of the demand for that site's services.

Table 7-5. Summary of Cicchetti, Seneca, and Davidson [1969] Participation Models

	Equations [a]	
Activity	Probability of participation	Level of participation
Water-based		
Swimming	Marginal effect of income on probability changes with level of income	Effect sensitive to region of residence
Water skiing	Constant marginal effect [b]	Income not a significant determinant
Other boating	Constant marginal effect [b]	Marginal effect of income changes with level of income
Canoeing	Constant marginal effect [b]	Income not a significant determinant
Other Activities		
Camping developed	Income not a significant determinant	Constant marginal effect of income

[a] These results are based on the estimates reported in Chapter 5 of Cicchetti, Seneca, and Davidson [1969].

[b] These estimated parameters were substantially smaller in numerical magnitude than the estimated parameter for income in the probability equation for. fishing.

Finally the overall explanatory power, as measured by R^2, is also quite variable across sites. In some cases, such as sites 303 (Beaver Lake, Arkansas), 313 (Ft. Randall, Lake Francis Case, South Dakota), 314 (Grapevine Lake, Texas), and 337 (Proctor Lake, Texas), the R^2 is comparable to most cross-sectional analyses. For the remainder it is somewhat low, indicating that there may be other major factors influencing these site demands.

7.5.4 Results for the Tailored Models

It should be acknowledged that while the basic model provides a plausible specification for a site demand equation, there may well be a number of other determinants of these demands. Indeed, the low R^2 would certainly support this conclusion. Since the overall objective is to develop a general model for projecting the effects of changes in any water-based site's characteristics on the site demand, site demand equations must adhere to a common specification. Nonetheless, this does not prevent an appraisal of the sensitivity of the basic model's parameter estimates to the inclusion of additional variables. As a consequence, the analysis plan considered a wide array of alternative specifications of each demand function. These models include additional socioeconomic information --age, sex, education, and race--as well as an attitudinal variable (coded as zero and 1), with 1 designating individuals who regarded outdoor recreation as very important in comparison to their other interests (R EC IMP).

Table 7-6. Comparison of Basic Model With Tailored Model: Coefficient for (TC+MC)

Site name	Site No.	Basic model	Range of estimates tailored models
Lock and Dam No. 2 (Arkansas River Navigation System)-, AR	302	-0.0125	-0.010 to -0.013
Beaver Lake, AR	303	-0.0066	-0.0060 to -0.0070
Blakely Mt. Dam, Lake Ouachita, AR	307	-0.0079	-0.0070 to -0.0080
Cordell Hull Dam and Reservoir, TN	310	-0.0139	-0.0013 to -0.0015
Dewey Lake, AR	312	-0.0024	-0.0020 to -0.0030
Grapevine Lake, TX	314	-0.0073	-0.0060 to -0.0090
Greers Ferry Lake, AR	315	-0.0065	-0.0060 to -0.0070
Genada Lake, MS	316	-0.0095	-0.0080 to -0.0100
Lake Washington Ship Canal, WA	320	-0.0037	-0.0030 to -0.0400
Melvern Lake, KS	322	-0.0079	-0.0070 to -0.0090
Millwood Lake, AR	323	-0.0081	-0.0070 to -0.0090
Mississippi River Pool No. 3, MN	324	-0.0057	-0.0050 to -0.0060
Mississippi River Pool No. 6, MN	325	-0.0074	-0.0070
Ozark Lake, AR	331	-0.0046	-0.0030 to -0.0050
Philpott Lake, VA	333	-0.0087	-0.0070 to -0.0090
Pine River, MN	334	-0.0017	-0.0010 to -0.0020
Proctor Lake, TN	337	-0.0134	-0.0013 to -0.0014
Sardis Lake, MS	340	-0.0030	-0.0030 to -0.0040
Whitney Lake, TX	344	-0.0025	-0.0020 to -0.0030

Table F-5 in Appendix F presents a sample of these models for a selected set of the 43 sites. These cases represent the site demands where one or more alternative specifications would have been regarded as equivalent or better to the basic model. In evaluating these models, the focus was on the estimated parameters for variables that were common between the basic model and each variation to it. In general, the most important parameter--the coefficient for the implicit price--was remarkably stable. Table 7-6 provides a comparison of these estimates from the tailored specifications with the basic model estimates reported in Table 7-4.

Since it is widely acknowledged in the econometrics literature that pretesting and sequential estimation practices affect the kinds of inferences that can be drawn concerning the properties (i.e. , unbiasedness, efficiency, etc.) of the "final" model's estimated parameters, these types of sensitivity analyses gauge whether the decisions required to select the final models were important to the parameters of central importance to the overall objectives. * The general criteria used for selecting the specifications reported in Table 7-4 were based on three considerations; (1) agreement between the sign of the estimated parameters with what was expected from economic theory; (2) statistical significance of the estimates using conventional criteria as appropriate indexes of the precision of the estimates; and (3) robustness of the measured effects for important variables (such as TC+MC) to model specifications.

7.5.5 Evaluation of Measures of the Opportunity Cost of Travel Time

Tables 7-7 and 7-8 report the results of two sets of tests for the basic model and tailored models, respectively. The tests have been structured to evaluate alternative definitions of the opportunity cost of travel time. The two models can be readily described. The first maintains that the wage rate is the most appropriate measure. This would imply that the measure of the time costs of travel, TC, can be added to the travel costs as in Equation (7.31). Alternatively, if, as several authors have argued, the opportunity cost is a different, constant multiple of the wage, the model should be written as:

$$\ln V_i = \bar{\alpha}_0 + \bar{\alpha}_1 TC_i + \bar{\alpha}_2 MC_i + \bar{\alpha}_3 INC_i + \& \quad . \tag{7.32}$$

Thus, if the wage rate is the appropriate measure of the opportunity cost of travel time, $\bar{\alpha}_1$ should equal $\bar{\alpha}_2$. Rejection of this null hypothesis would therefore provide support for the arguments against the use of the wage rate as the opportunity cost. The sixth column of Table 7-7 reports the relevant F-statistic and significance levels for this hypothesis using the basic model. Overall the hypothesis is rejected for 9 of the 43 sites with the basic model at the 5-percent significance level. These decisions are generally repeated with the tailored models for the sites reported in both cases.

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*This approach is clearly in the spirit of the suggestion made by Klein et al. [1978] for dealing with estimation problems.

Table 7-7. F-Test for Restriction of General\ Model

Hypothesis 1, Full-Time Cost: LN Visits = $\alpha_0 + \alpha_1$ (T + M) Cost + α_3 Income

Hypothesis 2, Cesario Hypothesis:[a] LN Visits = $\tilde{\alpha}_0 + \tilde{\alpha}_1$ (T 1/3 + M) Cost + $\tilde{\alpha}_3$ Income

Unrestricted model: LN Visits = $\bar{\alpha}_0 + \bar{\alpha}_1$ T Cost + $\bar{\alpha}_2$ M Cost + $\bar{\alpha}_3$ Income

Site	Site number	Sum of squared residuals, Hypothesis 1	Sum of squared residuals, Hypothesis 2	Sum of squared residuals, unrestricted" model	F- statistic level of significance	
					Ho: $\alpha_1 = \alpha_2$	Ho: a = $1/3\bar{\alpha}_2$
Allegheny River System, PA	300	45.27	45.27	44.99	0.53	0.53
Arkabutla Lake, MS	301	24.84	24.12	23.93	0.14	0.50
Lock and Dam No. 2 (Arkansas River Navigation System), AR	302	7.58	8.02	6.91	0.07	0.02
Beaver Lake, AR	303	104.64	109.61	104.09	0.27	0.01
Belton Lake, TX	304	25.90	25.82	23.71	0.04	0.04
Benbrook Lake, TX	305	11.52	11.29	11.20	0.28	0.56
Berlin Reservoir, OH	306	62.13	61.93	61.70	0.43	0.56
Blakely Mt. Dam, Lake Ouachita, AR	307	45.00	44.02	43.96	0.15	0.73
Canton Lake, OK	308	41.48	43.49	41.25	0.53	0.06
Clearwater Lake, MO	309	45.84	45.51	45.37	0.40	0.64
Cordell Hull Dam and Reservoir, TN	310	47.11	46.18	46.18	0.16	0.99
DeGray Lake, AR	311	22.45	22.62	22.45	0.99	0.56
Dewey Lake, AR	312	16.03	16.45	15.91	0.58	0.24
Ft. Randall, Lake Francis Case, SD	313	24.34	26.34	24.05	0.46	0.04
Grapevine Lake, TX	314	22.64	25.40	21.34	0.02	0.01

[a](T 1/3 + M) cost represents the total cost of a round trip where travel time is evaluated at one-third of the predicted wage rate.

(continued)

Table 7-7. (continued)

Hypothesis 1, Full-Time Cost:	LN Visits = $\alpha_0 + \alpha_1$ (T + M) Cost + α_3 Income
Hypothesis 2, Cesario Hypothesis: [a]	LN Visits = $\tilde{\alpha}_0 + \tilde{\alpha}_1$ (T 1/3 + M) Cost + $\tilde{\alpha}_3$ Income
Unrestricted model:	LN Visits = $\bar{\alpha}_0 + \bar{\alpha}_1$ T Cost + $\bar{\alpha}_2$ M Cost + $\bar{\alpha}_3$ Income

Site	Site number	Sum of squared residuals, Hypothesis 1	Sum of squared residuals, Hypothesis 2	Sum of squared residuals, unrestricted model	F- statistic level of significance	
					Ho: $\bar{\alpha}_1 = \bar{\alpha}_2$	Ho: $\bar{\alpha} = 1/3\bar{\alpha}_2$
Greers Ferry Lake, AR	315	110.96	120.65	104.06	0.01	0.01
Genada Lake, MS	316	27.65	27.39	27.39	0.41	0.99
Herds Creek Lake, TX	317	30.61	30.32	30.18	0.40	0.63
Isabella Lake, CA	318	23.59	23.45	23..45	0.61	0.99
Lake Okeechobee and Waterway, FL	319	21.84	22.71	21.59	0.59	0.26
Lake Washington Ship Canal, WA	320	26.22	28.31	24.90	0.15	0.02
Leech Lake, MN	321	21.18	20.78	20.64	0.29	0.59
Melvern Lake, KS	322	31.37	31.16	31.15	0.59	0.91
Millwood Lake, AR	323	28.67	28.36	28.35	0.46	0.90
Mississippi River Pool No. 3, MN	324	20.68	22.59	20.63	0,74	0.04
Mississippi River Pool No. 6, MN	325	37.73	39.47	37.49	0.51	0.06
Navarro Mills Lake, TX	327	23.44	23.59	23.30	0.64	0.50
New Hogan Lake, CA	328	30.71	30.76	30.60	0.72	0.66
New Savannah Bluff Lock & Dam, GA	329	16.67	16.65	16.44	0.49	0.51
Norfork Lake, AR	330	18.45	19.58	17.53	0.17	0.04
Ozark Lake, AR	331	24.31	25.53	21.93	0.03	0.01
Perry Lake, KS	332	12.06	12.01	12.00	0.73	0.89

[a](T 1/3 + M) cost represents the total cost of a round trip where travel time is evaluated at one-third of the predicted wage rate.

(continued)

Table 7-7. (continued)

Hypothesis 1, Full-Time Cost: LN Visits = $\alpha_0 + \alpha_1$ (T + M) Cost + α_3 Income

Hypothesis 2, Cesario Hypothesis:[a] LN Visits = $\tilde{\alpha}_0 + \tilde{\alpha}_1$ (T 1/3 + M) Cost + $\tilde{\alpha}_3$ Income

Unrestricted model: LN Visits = $\bar{\alpha}_0 + \bar{\alpha}_1$ T Cost + $\bar{\alpha}_2$ M Cost + $\bar{\alpha}_3$ Income

Site	Site number	Sum of squared residuals, Hypothesis 1	Sum of squared residuals, Hypothesis 2	Sum of squared residuals, unrestricted model	F-statistic level of significance	
					Ho: $\bar{\alpha}_1 = \bar{\alpha}_2$	Ho: $\bar{\alpha} = 1/3\bar{\alpha}_2$
Philpott Lake, VA	333	10.42	9.97	9.85	0.17	0.52
Pine River, MN	334	22.96	23.44	21.25	0.02	0.01
Pokegama Lake, MN	335	37.31	38.26	36.81	0.35	0.11
Pomona Lake, KS	336	14.42	14.18	13.27	0.13	0.18
Proctor Lake, TN	337	13.25	12.41	12.24	0.05	0.42
Rathbun Reservoir, 10	338	21.70	20.83	17.29	0.01	0.03
Sam Rayburn Dam & Reservoir, TX	339	34.21	33.16	33.15	0.16	0.89
Sardis Lake, MS	340	64.10	66.42	52.76	0.01	0.01
Waco Lake, TX	343	20.07	20.02	17.23	0.01	0.01
Whitney Lake, TX	344	113.80	115.40	96.77	0.01	0.01
Youghiogheny River Lake, PA	345	20.17	21.35	18.17	0.10	0.04

[a] (T 1/3 + M) cost represents the total cost of a round trip where travel time is evaluated at one-third of the predicted wage rate.

Table 7-8. F-Test for Restriction of Tailored Models[a]

Site	Site number	F-statistic level of significance				
		Model 1	Model 2	Model 3	Model 4	Model 5
Lock and Dam No. 2 (Arkansas River Navigation System), AR	302	0.07	0.07	0.05	0.03	0.05
Beaver Lake, AR	303	0.29	0.32	0.06	0.20	0.34
Blakely Mt. Dam, Lake Ouachita, AR	307	0.18	0.13	0.17	0.30	0.30
Cordell Hull Dam and Reservoir, TN	310	0.20	0.20	0.46	0.16	0.22
Dewey Lake, KY	312	0.49	0.63	0.16	0.58	0.87
Grapevine Lake, TX	314	0.03	0.04	0.02	0.03	0.05
Greers Ferry Lake, AR	315	0.01	0.01	0.01	0.01	0.02
Grenada Lake, MS	316	0.35	0.47	0.36	0.35	0.20
Lake Washington Ship Canal, WA	320	0.59	0.20	0.10	0.18	0.16
Melvern Lake, KS	322	0.41	0.61	0.46	0.61	0.99
Millwood Lake, AR	323	0.49	0.46	0.84	0.46	0.46
Mississippi River Pool No. 3, MN	324	0.99	0.88	0.88	0.64	0.75
Mississippi River Pool No. 6, MN	325	0.54	0.28	0.56	0.76	0.55
Ozark Lake, AR	331	0.03	0.02	0.03	0.03	0.13
Philpott Lake, WA	333	0.16	0.08	0.17	0.14	0.04
Pine River, MN	334	0.03	0.03	0.02	0.02	0.02
Proctor Lake, TX	337	0.06	0.09	0.16	0.07	0.05
Sardis Lake, MS	340	0.01	0.01	0.01	0.01	0.01
Whitney Lake, TX	344	0.01	0.01	0.01	0.01	0.01

[a]F-tests are calculated using the five restricted models in Table 7-6 against unrestricted models where travel time and mileage cost are separate.

The second hypothesis considers Cesario's suggestion that the opportunity cost is a multiple of the wage rate. The explanation for the parametric treatment of this hypothesis stems from the definitions of the components of the cost of a trip. A TC, the time costs of travel, is defined as the predicted wage rate, say w times the travel time, t, or $\hat{w}t$. If the opportunity cost of travel time is some multiple, k (k < 1) of the wage rate and can be assumed to be constant across individuals, the true measure of TC (designated $\widetilde{TC}$) should be $k\hat{w}t$. Both travel costs and the time costs of travel should, when the latter is correctly measured, have the same effect on the demand for a site's services. Thus, if the maintained hypothesis ($\widetilde{TC} = k\hat{w}t$) is correct, α_1 can be expected to be equal to α_2. However, k cannot be measured .- By using $\hat{w}t$ as a proxy and assuming that k is constant, the estimates of α_1 in the model using Tc = $\hat{w}t$ can be expected to be $\bar{\alpha}_1 = k\alpha_1$. Since it is expected that $\tilde{\alpha}_1 = \alpha_1$ and that $\hat{\alpha}_2$ will, under ideal conditions, equal α_2, the Cesario suggestion can be treated as the hypothesis that $\bar{\alpha}_1 = k\alpha_2$ in terms of Equation (7.32). Since Cesario's specific suggestion was that k = 1/3, the second hypothesis is $\alpha_1 = 1/3\ \alpha_2$. The seventh column of Table 7-7 reports the results for this test. Nearly twice as many sites (16) reject this null hypothesis with the basic model .

Thus, there is greater support for the use of the wage rate as a measure of the opportunity cost of travel time than the Cesario one-third adjustment to the wage. However, there is no unambiguous choice, because some sites fail to reject both sets of restrictions.

7.6 FURTHER EVALUATION OF THE TRAVEL COST MODELS

Section 7.5 presented estimates of the final models for each of 43 recreation sites. As noted earlier, the methodology developed in this chapter requires that the individual site demand equations adopt the same specification. In some cases this specification would have been adopted as "best, " and, for others, the choice was not as clearcut. As a consequence, it was necessary to evaluate the sensitivity of important demand parameter estimates to the model specification. There are several additional aspects of these travel cost models that require further consideration. Therefore, this section collects the results of the further evaluations of these models. This analysis was conducted in an attempt to identify potential shortcomings with the models and to appraise their importance for the estimated values. Most of these difficulties arise from either econometric problems with the model or limitations that would be expected based on the economic model of consumer behavior developed at the outset of the chapter.

The first aspect of these travel cost models requiring further consideration arises from the data and the model specification themselves. The visit measure used in this analysis is a positive integer by definition. This raises a number of potential econometric problems. For the purpose of this study these problems have been ignored. * However, where possible, appraisals have been made

*The implications of these features for the site demand models and benefit estimates are currently being evaluated using appropriately structured maximum likelihood estimators and recent method of moments approximations proposed by Greene [1983] .

of the potential implications of one of the most important aspects of the sample--that it observes only the behavior of individuals who have visited each site at least once. To evaluate the potential importance of the bias in ordinary least-squares estimates as a result of the truncated form of the measure of site usage, Olsen's [1980] method of moments approximation of the maximum likelihood estimates for models with truncated dependent variables has been used.

The Olsen method relies on approximating the mean of the conditional distribution for the dependent variable (i.e., $E(y \mid y > 0)$). His proposed scaling factors use a first-order approximation to derive a relationship between the ordinary least-squares estimates of a model's parameters and the maximum likelihood estimates. They can be estimated from the moments of the incomplete (i. e., truncated) distribution. These scaling factors are used to gauge the magnitude of the differences between an approximate maximum likelihood estimator and ordinary least squares. Thus, as Olsen suggests, they provide a crude index of the potential severity of the problems with truncation. Greene [1981] has also proposed an approach for adjusting ordinary least-squares estimates in the present Tobit and truncated dependent variable 'models. He found that Olsen's approximation tends to overstate the bias. Olsen's approximation will be closest to Greene's approach for models with small coefficients of determination (i.e., R^2). As R^2 increases the Olsen adjustment will tend to overstate the extent of bias. Thus, this study's screening of estimated site demand models provides a fairly conservative basis for gauging the bias due to the truncation of the measure of site usage. Table 7-9 reports these scaling factors for the 33 sites in which the general model performed well.

The scaling factors in the fourth column of Table 7-9 can be interpreted as the multiplicative adjustment coefficients required for the ordinary least-squares parameter estimates to approximate the maximum likelihood estimates (based on the assumption of a truncated distribution). Thus, for site No. 301, the maximum likelihood estimates would be 15 percent greater than the ordinary least-squares parameter estimates in absolute magnitude. These comparisons suggest that several sites exhibit pronounced truncation effects. For at least 11 of these sites, the bias associated with the ordinary least-squares estimates may well be quite substantial. As a consequence, the potential for differential bias in the estimates of these site demand functions is accounted for in the final model. That is, the generalized least-squares estimates relating the features of each site demand function to the site's characteristics have been derived using two samples--one including all sites with complete data (i.e., sites with plausible demand models and complete information on water quality and other site characteristics) and a second omitting those sites with potentially important truncation effects.

A second source of qualification to the travel cost demand model arises from the assumption that all users of each individual site have the same derived demand for that site's services. In most cases, disparities in onsite time could not be accounted for. Moreover, it has not been possible to adjust for the different mixes of activities undertaken by different individuals at the

Table 7-9. Effects of Truncation on the Travel Cost Models' Estimates

Site name	Site number	Incomplete mean/ standard deviation	Olsen ML scaling factor[a]
Arkabutla Lake, MS	301	2.115	1.15
Lock & Dam No. 2 (Arkansas River Navigation System), AR	302	4.115	1.01
Beaver Lake, AR	303[b]	0.975	13.55
Belton Lake, TX	304	2.080	1.18
Benbrook Lake, TX	305	3.001	1.01
Blakely Mt. Dam, Lake Ouachita, AR	307	1.425	2.18
Canton Lake, OK	308	1.299	2.92
Cordell Hull Dam & Reservoir, T~	310	1.855	1.29
DeGray Lake, AR	311	1.818	1.34
Dewey Lake, KY	312[b]	0.866	13.55
Ft. Randall, Lake Francis Case, SD	313	0.817	13.55
Grapevine Lake, TX	314	2.458	1.05
Greers Ferry Lake, AR	315	1.493	1.85
Grenada Lake, MS	316	2.401	1.07
Herds Creek Lake, TX	317[b]	1.374	2.44
Isabella Lake, CA	318	1.169	5.33
Lake O keechobee and Waterway, FL	319[b]	1.119	7.87
Lake Washington Ship Canal, WA	320[b]	0.876	13.55
Leech Lake, MN	321	0.994	13.55
Melvern Lake, MS	322	1.269	3.30
Millwood Lake, AR	323[b]	1.739	1.39
Mississippi River Pool No. 3, MN	324	1.020	13.55
Mississippi River Pool No. 6, MN	325	1.557	1.75
New Savannah Bluff Lock & Dam, GA	329	2.137	1.15
Norfork Lake, AR	330[b]	1.139	6.69
Ozark Lake, AR	331	1.577	1.67
Philpott Lake, VA	333	2.413	1.07
Pine River, MN	334[b]	0.949	13.55
Pokegama Lake, MN	335[b]	1.018	13.55
Proctor Lake, TX	337	1.960	1.25
Sam Rayburn Dam & Reservoir, TX	339	1.474	1.95
Sardis Lake, MS	340	3.107	1.01
Whitney Lake, TX	344	1.821	1.34

[a]These scaling factors are assigned approximately using Olsen's Table I by selecting the closest value for the reported mean to standard deviation with the incomplete distribution.

[b]These sites were omitted for truncation bias in second estimation of the model.

same site. * Thus, it might be conjectured that the same demand model is not equally well suited to all survey respondents. Such a hypothesis would imply that the parameter estimates would be sensitive to sample composition. That is, deleting individual observations associated with individuals with especially long onsite time or rather different sets of activities may well have a pronounced effect on the ordinary least-squares estimates of the model's parameters. Moreover, this impact may be differentially important to subsets of the sites considered for this analysis because there are substantial differences in the number of respondents for these sites.

To investigate this issue, DFBETA was calculated (Belsley, Kuh, and Welsch's [1980] regression diagnostic). This index was designed to act as an aid in identifying influential or outlying observations. It is not a statistical test. It has been used to judge the "influence" of specific observations on this study's estimates of site demand parameters. With this evaluation, it is then possible to consider the features of these survey respondents to evaluate whether there are economic reasons for expecting that the demand patterns of these individuals must be explained in a different framework. The specific index used is defined as the difference between the ordinary least-squares estimate for each parameter based on the complete sample and the corresponding estimate based on the sample with the omission of one observation. These indexes were calculated for each parameter and each observation. A review of these estimates indicated that no single observation had an important effect on the estimated parameters. This conclusion was found for all sites, including those with a somewhat limited number of sampled recreationists. While this finding does not guarantee that the effects of onsite time and the mix of recreation activities are inconsequential influences on site demand, it does suggest that they are unlikely to have pronounced effects on these estimates.

The final aspect of the travel cost models that requires further consideration stems from the relationship between decisions on the number of trips to each recreation facility and the amount of time spent onsite per trip. As noted previously, the onsite time measure relates to the trip each respondent was undertaking at the time that he was interviewed, but there is no information as to how representative this trip was. That is, the survey does not identify for all visits during the season the amount of time spent onsite per trip. Thus, the analyses of travel and onsite time costs (both the time and the distance components) implicitly assume that the onsite time for the current trip is a good indicator of the onsite time for all past trips.

If this assumption is reasonable, then it is also plausible to consider the prospects for a simultaneous equation model to describe the decisions for visits to a site and the time on the site per trip. When using simultaneous equation models with the Federal Estate Survey data, two aspects of consistency in recreation choices must be considered.

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*The feasibility of including measures of the activities undertaken into the second stage models for the estimated site demand parameters is currently being investigated.

First, individuals may decide the amount of time to be spent onsite--first based on the activities they wish to undertake and then based on the number of visits to a site to engage in these activities. Within this decision framework, onsite time can be treated as exogenously determined. Visits may be conditional upon these onsite time choices. This would not imply that onsite time was not important to decisions on visits to a recreation facility. Rather, it would suggest that they are not joint decisions. Indeed, for some cases it may be necessary to segment the samples of users according to their lengths of stay on the site. *

Secondly, the onsite time may not be constant for all trips, and thus the measure available for per-trip time onsite is inappropriate. These prospective difficulties in evaluating the relationship between visit and onsite time decisions will therefore influence any effort to model their respective roles in recreation site demand functions. Nonetheless, in an attempt to account for these simultaneous equation effects, onsite time has been treated as an endogenous variable, and a variety of specifications have been considered for it as well as for the site demand models themselves. in general, this study has attempted to instrumentalize the measures of the variable costs of onsite time. More specifically, onsite cost is specified as a nonlinear combination of exogenous and endogenous variables as a result of the respective roles for the opportunity cost of time and onsite time.

Following conventional practice (see Kelejian [1971]), the combination is treated as a right-hand-site endogenous variable and the models were estimated with two-stage least squares. † The first-stage instruments were composed of the included predetermined variables in each specification for the travel cost model along with age, sex, and a qualitative variable to reflect whether the recreation activities included camping. Several variations in these instruments were considered. However, this set of variables provided acceptable models for the largest set of site demands. Table 7-10 reports the two-stage estimates for 21 of the sites. ‡ As with earlier results (i.e. , using ordinary least squares and ignoring onsite time), the role of income appears quite limited for nearly all sites. Only one site demand, Millwood Lake, Arkansas (No. 323) yields a statistically significant estimate for the coefficient of family income. The results for onsite time are encouraging but certainly not clearcut. As suggested by the theoretical model, onsite time (SCOST) affects the “price” of a trip to the site (since the model assumes all trips have the same onsite time), and it also contributes to the production of recreation service flows.

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*Our analysis with regression diagnostics indicated that these problems were unlikely to be present in our models because the results were not sensitive to deleting individual observations.

†Ideally, the Kelejian method calls for polynomials in the predetermined variables as first-stage instruments. This was not attempted in our case because of the limited number of observations for several of the sample recreation sites.

‡The 21 sites are the result of two screenings of the 43 sites in the Survey. The first screening eliminates 10 sites with implausible demand functions. The second eliminates 12 sites that experienced truncation bias.

Based on the first of these impacts, it would be expected to have a negative impact on the demand for visits to a site. It is a component of the price of a visit. In addition, however, increases in the time spent onsite provide one means of substituting for visits. Thus, one might hypothesize a positive "substitution" effect on the demand for trips to a recreation site. Of course, the demand model reflects a composite of these two influences.

The empirical results are consistent with the presence of these opposing influences on site demand. For some sites, the effect of SCOST is positive, while, for others, it is negative. Five of the 21 site demands exhibit statistically significant estimates for on site costs, based on the asymptotic t-ratios. In all of these cases the estimated coefficients are negative.

Table 7-10. Two-Stage Least-Squares Estimates for Selected Travel Cost Site Demand Models

		Estimated travel cost model s[a]					
Site Name	Site No.	Intercept	TC+MC	SCOST	INC	AGE	R^2
Beaver Lake, AR	303	1.705	-0.0056	-0.0W3	-0.000003	-0.0009	0.42
		(11.45)	(-8.12)	(-2.21)	(-0.61)	(-0.27)	
Benbrook Lake, TX	305	1.999	-0.0052	-0.0001	0.000003	-o. W20	0.31
		(6.05)	(-3.84)	(-0.55)	(0.34)	(-0.29)	
Blakely Mt. Dam, Lake Ouachita, AR	307	1.721	-0. 0081	-0.0002	-0. 000009	0.0048	0,21
		(3.077)	(-4.57)	(-0.40)	(-0.81)	(0.78)	
Canton Lake, OK	308	1.787	-0.0172	-0.0008	0.000005	o. W43	0.26
		(5.83)	(-2.83)	(-0.60)	(0.47)	(0. S8)	
Cordell Hull Dam & Reservoir, TX	310	1.603	-0.0137	-0.0002	0.000003	O. W72	0.35
		(7.58)	(-4.53)	(-0.48)	(0.35)	(1.71)	
DeGray Lake, KY	311	1.587	-0. 0083	-0.0004	-0. 000002	0.0104	0,21
		(4.51)	(-3.24)	(-1.38)	(-0.21)	(1.44)	
Ft. Randall, Lake Francis Case, SD	313	1.778	-0. W42	-o. W21	0.000009	-0.W87	0.38
		(4.74)	(-2.43)	(-2.28)	(0.79)	(-0.94)	
Grapevine Lake, TX	314	2.154	-0.W53	-0.0001	0.000009	-0.0129	0.50
		(12.73)	(-5.06)	(-2.31)	(1.72)	(-2.91)	
Greers Ferry Lake, AR	315	1.607	-0.0066	o.00002	0.000009	-0.0045	0.28
		(10.60)	(-7.70)	(0.08)	(1.48)	(-1.09)	
Grenada Lake, MS	316	1.551	-o. W73	-0. 0016	0.00001	0.0100	0.26
		(5.06)	(-2.86)	(-2.64)	(0.71)	(1.99)	
Herds Creek Lake, TX	317	1.938	-0.0050	-0.0001	-0.00002	-0.W30	0.20
		(5.81)	(-2.06)	(-0.19)	(-1.77)	(-0.36)	
Lake Washington Ship Canal, WA	320	0.505	-0. 0038	0.0465	o.00002	-0.0018	0.21
		(0.66)	(-2.40)	(1.07)	(0.78)	(-0.15)	
Leech Lake, MN	321	0.293	-0.0032	0.0004	0.000011	0.0069	0.17
		(0.79)	(-2.33)	(1.26)	(0.95)	(0.93)	
Millwood Lake, AR	323	0.829	-0.0091	0.000009	0.00002	0.0134	0.30
		(2.33)	(-3.88)	(0.02)	(2.54)	(1.88)	
Mississippi River Pool, No. 6, MN	325	1.198	-0.0062	-0.0006	0.00002	0.0070	0.24
		(3.81)	(-3.24)	(-1.66)	(1.95)	(0.97)	
Norfork Lake, AR	330	0.666	-0.W55	-0.0008	0.00001	0.0149	0.20
		(1.65)	(-2.85)	(-0.28)	(0.91)	(1.55)	
Philpott Lake, MN	333	2.209	-o. 0074	-0.0007	0.000002	-0.0062	0.47
		(7.21)	(-3.75)	(-1.49)	(0.18)	(-1.07)	
Pokegama Lake, MN	335	1.344	-0.0030	-0.0004	-0. 000009	0.0020	0.24
		(3.62)	(-3.54)	(-1.32)	(-0.86)	(0.34)	
Proctor Lake, TX	337	1.783	-0.0149	0.0003	0.000002	0.0049	0.56
		(6.47)	(-5.99)	(0.84)	(0.33)	(1.01)	
Sam Rayburn Dam & Reservoir, TX	339	1.157	-0.0098	-0.0001	0.000002	0.0102	0,17
		(3.38)	(-2.92)	(-0.29)	(0.19)	(2.00)	
Whitney Lake, TX	344	1.527	-0. 0027	-0.0009	0.000006	0.0078	0.10
		(8.30)	(-1.44)	(-4.15)	(1.11)	(1.88)	

[a]The numbers in Parentheses below the estimated coefficients ● re asymptotic t-ratios for the null hypothesis of no association.

The remaining sites also were modeled within a simultaneous framework. However, in these cases the parameters estimates were inferior to those derived using ordinary least squares under the assumption of constant onsite time. As a rule, the estimated effect of travel cost (TC+MC) was not statistically significant and, in some cases, suggested a positive effect on site demand. Moreover, the estimated effects of onsite costs were generally statistically insignificant. Thus, the models reported in Table 7-10 are the cases in which the simultaneous estimates were judged to be equivalent or better than the ordinary least-squares results reported in Section 7.5.

These results are important for two reasons. They attempt to deal with onsite time costs and travel costs within a single demand framework. Most authors (see Brown and Mendelssohn [1980] as a notable example) have either attempted to partition their samples according to the time spent onsite and estimate separate demand models for each grouping or have assumed that onsite time was not important to the decisions for trips to a recreation facility. This latter assumption might be the result of features of the recreation activities undertaken and site selected or simply because the time onsite was approximately constant across trips.

Table 7-11. Comparison of Ordinary Least-Squares and Two-Stage Least-Squares Estimates of Travel Cost ($TC_i + MC_i$) Parameters

Site name	Site No.	Ordinary least-squares estimate	Two-stage least-squares estimate
Beaver Lake, AR	303	-0.0066	-0.0056
Benbrook Lake, TX	305	-0.0054	-0.0052
Blakely Mt. Dam, Lake Ouachita, AR	307	-0,0079	-0.0081
Canton Lake, OK	308	-0.0206	-0.0172
Cordell Hull Dam & Reservoir, TX	310	-0.0139	-0.0137
De Gray Lake, AR	311	-0.0070	-0.0083
Ft. Randall, Lake Francis Case., SD	313	-0.0066	-0.0042
Grapevine Lake, TX	314	-0.0073	-0.0053
Greers Ferry Lake, AR	315	-0.0065	-0.0066
Grenada Lake, MS	316	-0.0095	-0.0073
Herds Creek Lake, TX	317	-0.0050	-0.0050
Lake Washington Ship Canal, WA	320	-0.0037	-0.0038
Leech Lake, MN	321	-0.0022	-0.0032
Millwood Lake, AR	323	-0.0081	-0.0091
Mississippi River Pool No. 6, MN	325	-0.0074	-0.0062
Norfork Lake, AR	330	-0.0047	-0.0055
Philpott Lake, VA	333	-0.0087	-0.0074
Pokegama Lake, MN	335	-0.0033	-0.0030
Proctor Lake, TX	337	-0.0134	-0.0149
Sam Rayburn Dam & Reservoir, TX	339	-0.0094	-0.0098
Whitney Lake, TX	344	-0.0025	-0.0027

Table 7-12. Hausman Test for Differences Between Two-Stage Least-Squares and Ordinary Least-Squares Estimates

Site	$\hat{\alpha}_1^{2SLS} - \hat{\alpha}_1^{OLS}$	$\hat{\alpha}_1^{2SLS}$	$\hat{\alpha}_1^{OLS}$	$VAR_{2SLS} - VAR_{OLS}$	t-statistic
303	-0.0010	0.0000005	0.0000003	0.000447	2.237
305	0.0002	0.0000018	0.0000017	0.000316	0.633
307	-0.0002	0.0000031	0.0000024	0.000837	-0.239
308	0.0034	0.0000368	0.0000152	0.004648	0.731
310	0.0002	0.0000092	0.0000054	0.001949	0.103
311	-0.0013	0.0000066	0.0000054	0.001095	-1.187
313	0.0024	0.0000030	0.0000012	0.001342	1.788
314	0.0020	0.0000011	0.0000007	0.000633	3.160
315	-0.0001	0.0000007	0.0000005	0.000447	-0.224
316	0.0022	0.0000065	0.0000047	0.001342	1.639
317	-0.0000248	0.0000058	0.0000056	0.000447	-0.05
320	-0.0001	0.0000027	0.0000010	0.001304	-0.077
321	-0.0010	0.0000018	0.0000014	0.000633	-1.580
323	-0.0010	0.0000055	0.0000041	0.001183	-0.845
325	0.0012	0.0000037	0.0000028	0.000949	1.264
330	-0.0008	0.0000037	0.0000034	0.000548	-1.460
333	0.0013	0.000003859	0.000003895	NA	NA
335	0.0003	0.0000007	0.0000005	0.000447	0.671
337	-0.0015	0.0000062	0.0000032	0.001732	-0.866
339	-0.0004	0.0000112	0.000011	0.000447	-0.894
344	-0.0002	0.0000034	0.0000019	0.001225	-0.163

Notes:

NA = The t-statistic could not be calculated as the variance since the ordinary least-squares estimate was greater than the two-stage least-squares estimate.

$\hat{\alpha}_1$ = the estimated coefficient of the travel plus mileage cost variable.

VAR = the variance of $\hat{\alpha}_1$.

2SLS = the two-stage least-squares model.

OLS = the ordinary least-squares model.

Of course, this perspective is implicitly adopted for the results in the previous Section. Thus, the second potential use of these findings is to gauge how important an error the failure to take account of simultaneity might be for the use of the general models to derive a benefit estimation framework. Table 7-11 reports a comparison of the ordinary least-squares estimates of the travel cost parameter versus the two-stage results for each of the sites where the two-stage least squares were judged to be at least as good as the ordinary least-squares models. Overall the results are quite similar. There are two types of comparisons that can be made between these estimates. As a practical matter, for benefit estimation, the numerical differences between the ordinary least squares and two-stage least-squares estimates are of concern. For the most part, the two sets of estimates for the (TC. + MC.) parameter are quite comparable. A second comparison involves considering 'whether the null hypothesis that the parameters for the travel and time cost variable were equal in the two models would be rejected based on these estimates. It is possible to develop an asymptotic test for this hypothesis using Hausman's [1978] approach to specification tests. Hausman derives an expression for the variance of the difference between two estimators of the same parameter. These estimators are defined for two hypotheses. It must be assumed that one is a consistent estimator under both the null and alternative hypotheses and that the second estimator is asymptotically efficient under the null but inconsistent under the alternative hypothesis. Given asymptotic normality and these assumptions the variance of the difference between the estimators is the difference in their respective variances. This application considers the difference between the two-stage least-squares and ordinary least-squares estimates of the coefficient for the travel cost variable. Constructing the corresponding t-ratio gives the following:

$$t = \frac{\hat{\alpha}_1^{2SLS} - \hat{\alpha}^{OLS}}{\sqrt{VAR(\hat{\alpha}_1^{2SLS}) - VAR(\hat{\alpha}_1^{OLS})}} . \quad (7.33)$$

Table 7-12 reports the details of the calculation of these test statistics. The t-ratio will follow an asymptotically normal distribution. Considering these statistics as an approximate basis for testing the difference between these coefficient estimates gives only two cases (Sites 303 and 314) in which the null hypothesis of equality would be rejected at the 5-percent significance level. Thus, these findings largely confirm the informal judgmental inspection and indicate that the ordinary least-squares models, which assume onsite costs to be constant, are unlikely to have serious errors because of this assumption.

7.7 ANALYZING THE ROLE OF WATER QUALITY FOR RECREATION DEMAND

The last step in the empirical modeling involves estimating the role of water quality and other site attributes in the demands for a site's services. The structure of the model has been detailed in Section 7.3. Thus, what remains to be presented is a specific description of the results of the application. The overall objective is to attempt to explain the observed variation in each of the estimated demand parameters across sites by the characteristics of those sites. With such a model, it is possible, in principle, to characterize the change in a site's demand in response to a change in any of the factors influencing those demand parameters. Thus, it would be feasible to evaluate the implications of a change in water quality for the demand for the site's services, even though the change has not been experienced. This ability arises from the fact that this model provides a general description of the factors that influence the features of site demands within a single framework.

The model has been derived from two subsets of the 43 site demand models described in Section 7.5 above. The first of these included 33 sites with plausible site demand functions.* The second restricts the sample further by eliminating 11 of these sites, based on estimates of the Olsen scaling factors reported in Table 7-9. As noted earlier, these scaling factors provide some indication of the prospects for bias due to the truncation in the measures of site usage. These 11 sites exhibited the largest values of the estimated scaling factor, ranging from 5.33 to 13.55. The specific sites eliminated from the sample are footnoted in Table 7-9 on page 7-45.

To develop estimates of the influence of site characteristics on the parameters describing a site's demand function, the attributes involved must be identified. As indicated in Section 7.4, the information on the site characteristics was obtained from U.S. Army Corps of Engineers. These data were augmented with information on water quality from the U.S. Geological Survey. As a rule, the Corps of Engineers data were measures of the size of the area and types of equipment available. The water quality information consisted of monthly readings from June through September of the year of the survey for seven measures of water quality, including dissolved oxygen, fecal coliform density, pH, biochemical oxygen demand, phosphates, turbidity, and total suspended solids. Two water quality indexes were also developed from these data for each month--the RFF water quality index (see Vaughan in Mitchell and Carson [1981]) and the NSF index. Since the specific features of these indexes were described in Section 7.4, their definitions will not be repeated here. Table 7-13 summarizes the primary site characteristics considered from the Corps of Engineers data.

Unfortunately, there are few a <u>priori</u> insights one can derive from economic theory regarding which subset of these variables is most likely to influence the estimated parameters of site demand models. While the primary focus was on the water quality measures, the analysis considered a number of alternative specifications, including subsets of the site characteristics reported in Table 7-13. The variables with the most consistent association with the demand parameters over the specifications considered included a measure of the size of the site (i.e. , SHORMILE), its access points (i.e. , MULTI + ACCESS), and the size of the water body relative to the overall site size (i.e. , AREAP/AREAT). This selection does not seem particularly surprising. Each variable can be interpreted as a crude measure of the capacity of the

*Appendix F presents the benefit estimates if all 33 sites are used in the model.

Table 7-13. Description of U.S. Army Corps of Engineers Data on Site Characteristics

Variable name	Description
SHORMILE	Total shoreline miles at the site during peak visitation period
AREAT	Total site area, land and water in acres
AREAP	Pool surface acreage on fee and easement lands during peak visitation period
MULTI	Number of developed , multipurpose recreation areas onsite
ACCESS	Number of developed onsite access areas
CORPICK	Number of Corps-managed onsite picnic locations
OTH PICK	Number of other agency-managed onsite picnic locations
CORCMPD	Number of Corps-managed developed camp sites
OTH CMPD	Number of other agency-managed developed camp sites
CORLN	Number of Corps-managed onsite boat launching lanes
OTH LN	Number of other agency-managed onsite boat launching lanes
DOCK PR	Number of onsite private boat docks
DOCKCO	Number of onsite community docks
FLOAT	Number of onsite floating facilities (e.g. , water ski jump, swimming floats, fishing floats, etc.)

site to provide services that would support different types of recreation service flows.

It was more difficult to isolate measures of water quality that appeared to influence the estimated site demand parameters. While the final generalized least-squares estimates for the determinants of site demand parameters seem exceptionally good, there are a number of reasons for caution in interpreting these findings, as shown by a review of the approaches used to develop them.

The modeling of the role of water quality considered a wide array of potential specifications of its effects, including each of the following:

- The monthly and average (across the 4 months of the summer season) readings for the two water quality indexes and measures of the variation in the index over the 4 months were considered.

- The monthly and average readings for specific components of the index (i.e. , dissolved oxygen, total suspended solids, etc.) were considered individually and in sets using existing information, where possible, to avoid the joint presence variables that might be measuring common phenomena.

- Temporal effects of individual pollutants were considered in an attempt to isolate "best" or most relevant indexes of water quality.

With a few notable exceptions these results led to either insignificant or unstable estimates of the effects of water quality on the site demand parameters.

Only in the case of dissolved oxygen did this pretesting of model specifications lead to a stable and statistically significant association between the variation in the estimated site demand parameters and the mean and variance in the level of dissolved oxygen over the summer period. This association is more clearcut with the smallest samples. Clearly, these findings are consistent with the earlier Vaughan-Russell [1981] and Nielsen [1980] analyses supporting the use of dissolved oxygen as an ideal measure of water quality for evaluating recreation fishing. Nonetheless, it should be acknowledged that the missing data problem is especially important for this study's water quality variables (see Section 7.4 above). The procedure has been to use the sample mean for those sites with missing water quality information. Thus, a smaller number of actual readings on water quality are what should be regarded as the basis of the measured association between water quality and the estimated site demand parameters. This does not imply that the use of means was inappropriate. Rather, it indicates that there was little observed variation in any of the water quality variables to associate with the estimated demand parameters.*

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*The indexes of water quality (i .e. , the RFF and NSF) tend to reduce the variation present in their components. Thus, there was very little variation in these indexes across sites.

Approximately half of the 22 sites in the restricted sample had complete water quality information. Thus, the preference for the dissolved oxygen measure might well be altered with more complete water quality data.

Table 7-14 reports the generalized least-squares estimates for the final model with both samples. * The parameters, α_0, α_1, and α_3, correspond to the general model specifications as given in Equation (7.31). These results clearly favor the model based on the restricted sample. Increases in the average level of dissolved oxygen would be improvements in water quality. The results using this restricted sample indicate that such increases would increase the demand at all implicit prices (i.e. , travel costs) and would also increase the degree of inelasticity in the demand curve. This second effect simply reflects the site's ability to support a wider range of recreation activities with the improved water quality.

Given the Poor Performance of income as a determinant of the demand for any one of the site's services, it is not surprising that the second step model for the income parameter is incapable of explaining the variation in the site demand parameters.

The most striking difference between the results estimated with the two samples arises with the estimated coefficients for the travel cost variable. The estimated effects of the site attributes, including the water quality measures, are all significantly different from zero and generally consistent in sign with a <u>priori</u> expectations. The differences between the two samples would seem to provide indirect evidence of the importance of truncation effects on the travel cost site demand models.

These generalized least-squares results do not include R* measures of goodness of fit because the conventional R* statistic is no longer confined to the 0 to 1 interval when calculated based on the generalized least-squares residuals. Thus, it does not have the same interpretation as the R* statistics reported with the ordinary least-squares results (see Cicchetti and Smith [1976] Appendix B for more details).

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*See Section 7.3 for a detailed discussion of the construction of the generalized least-squares estimator. It should be noted that Vaughan and Russell [1981] have used a similar methodology in their valuation of recreation fishing days. However, their approach combined the two equations by substituting the second step model for the determinants of site demand parameters (Equation 7.22) into Equation (7.21) to derive:

$$Y_i = X_i e A_i + \varepsilon_i .$$

This model includes interaction terms in the determinants of site demands and site attributes. It provides an equivalent description of the two-step approach used in this study. However, there is one advantage to the two-step approach in specification analysis of the models. It allows the specification of the determinants of site demand to be treated separately from the determinants of variations in site demand parameters. Each specification for the combined model includes assumptions about both.

Table 7-14. Generalized Least-Squares Estimates of Determinants of Site Demand Parameters[a]

Independent variable	$\hat{\alpha}_0$ 33 site	$\hat{\alpha}_0$ 22 site	$\hat{\alpha}_1$ 33 site	$\hat{\alpha}_1$ 22 site	$\hat{\alpha}_3$ 33 site	$\hat{\alpha}_3$ 22 site
Intercept	1.2959	1.5106	0.0005	-0.0246	0.53×10^{-5}	0.54×10^{-5}
	(3.768)	(4.081)	(0.203)	(-9.480)	(0.330)	(0.308)
SHORMILE	-0.0003	0.0003	0.47×10^{-6}	-0.13×10^{-4}	-0.14×10^{-7}	0.97×10^{-9}
	(-1.304)	(1.250)	(0.256)	(-6.763)	(-1.408)	(0.089)
(MULTI + ACCESS)	0.0017	-0.0059	-0.41×10^{-4}	0.77×10^{-4}	0.22×10^{-6}	0.47×10^{-6}
	(0.464)	(-1.502)	(-1.586)	(2.810)	(1.299)	(2.562)
AREAP/AREAT	-0.1686	-0.3950	-0.0025	0.0033	0.10×10^{-4}	-0.19×10^{-5}
	(-1.116)	(-1.752)	(-2.190)	(2.273)	(1.423)	(-0.181)
Mean dissolved oxygen	0.0049	0.0045	-4.2×10^{-4}	0.0002	-0.12×10^{-6}	-0.12×10^{-6}
	(1.220)	(1.065)	(-1.514)	(5.992)	(-0.642)	(-0.604)
Variance in dissolved oxygen	0.0003	0.0005	-0.17×10^{-5}	0.98×10^{-5}	-0.73×10^{-8}	0.94×10^{-10}
	(1.131)	(1.862)	(-0.751)	(4.077)	(-0.617)	(0.007)

[a]The numbers in parentheses below the estimated coefficients are the asymptotic t-ratios for the null hypothesis of no association.

7.8 A MEASURE OF THE BENEFITS OF A WATER QUALITY CHANGE

The Objective of the analysis of recreation behavior has been to develop a model capable of measuring the benefits associated with improving the water quality for any site that provides water-based recreation activities. Given information on the site characteristics found to be important determinants of site demand, it is possible to use the model for each demand parameter to estimate a "representative individual's" demand function for the desired water-based faci lity. Consequently, this section reports the results of such an application using information on the 13 sites along the Monongahela River that were used by the contingent valuation survey respondents.

Table 7-15 provides a description of these sites and their attributes. The model estimates the representative individual's demand for each site's services. Because the survey asked each respondent about his use of the river, including an identification of the site (or sites) used, it is possible to develop an estimate of these demand functions for each site. Moreover, because the model includes water quality information, the change in these demands can be estimated to accompany each of the water quality changes used in the survey instrument. In Chapter 8, this information provides the basis for a comparison of direct and indirect methods for measuring the

Table 7-15. Recreation Sites on the Monongahela River

Site name	Identification number	SHORMILE +	MULTI ACCESS	AREAP/ AR EAT
Pittsburgh area	15	2	1	0.99
The confluence of the Youghiogheny and Monongahela Rivers	16	2	2	0.99
Elrama	7	2	2	0.99
Town of Monongahela	8	3	4	0.99
Donora and Webster	9	2	1	0.99
Near Charleroi	20	3	4	0.96
California and Brownsville	21	12	6	0.96
Maxwell Lock and Dam	23	2	7	0.93
Point Marion	25	2	1	0.99
Morgantown	26	4	2	0.77
Fairmont	29	3	1	0.67
9th Street Bridge	37	1	1	0.99
Cooper's Rock	44	2	1	0.99

SOURCE: U.S. Army Corps of Engineers Resource Management System.

benefits from a water quality improvement. The direct methods correspond to the results from the survey, while the indirect methods use the information on the survey respondents' recreation behavior together with the generalized travel cost model developed in this chapter.

Seventy-five of the survey respondents were users of 1 or more of the 13 sites along this section of the Monongahela River. Because several individuals used more than one site, there are a total of 94 observations identified as an individual/site combination. These data provide the basis for constructing 94 separate demand models to evaluate the implications of water quality changes as measured by dissolved oxygen. For example, the model implied that the estimated price elasticities of demand (at the average travel costs for users in the survey used for the contingent valuation experiment) for the 13 recreation sites along the Monongahela River--the area for the contingent valuation survey--ranged from -0.069 to -0.075 at current water quality levels. Improving the water quality to permit game fishing would imply a change in DO from 45 to 64 (percent saturation). These changes reduce the absolute magnitude of the estimated demand elasticities to -0.052 to -0.059.

The benefits from a water quality improvement are measured by the increment to the ordinary consumer surplus experienced by each individual. * This increment can be defined for each individual user as follows:

$$B_{jk} = \int_{P_{jk}}^{P^*_{jk}} F_{jk}(p, WQ^*)dp - \int_{P_{jk}}^{P^*_{jk}} F_{jk}(p, WQ)\, dp \qquad (7.34)$$

where:

P_{jk} = travel cost (mileage plus travel time) experienced by the jth user to kth site

P^*_{jk} = maximum price the jth user would be willing to pay for the kth site's services (i .e. where the quantity demanded is zero)

WQ^* = improved water quality level

WQ = initial water quality level (i.e. , $WQ^* > WQ$)

$F_{jk}(\cdot)$ = demand function for the kth site's services by the jth user.

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*The measurement of the benefits from water quality improvement has ignored the potential for congestion effects. It has been assumed that conqestion is negligible both before and after the change in water quality. Without this assumption, the implications of management practices would need to be considered in the definition of the benefit measure (see McConnell and Sutinen [1983]).

Implementation of this benefit estimator required several amendments. The specification of the site demand functions in semilog terms implies that they will not have a price intercept. Rather, they asymptotically approach the horizontal (price) axis. To estimate a finite consumer surplus, a maximum for the price, P^*_{jk}, was selected to correspond to the maximum travel cost paid by any of the survey users of any Monongahela site. The specific value was $22.65 for a roundtrip, including both the mileage and time costs of travel.* This modification implies the benefit estimates for the water quality improvement will be ABCD as given in Figure 7-1, with P_j corresponding to the jth user's travel costs and P* the maximum value for the travel cost..

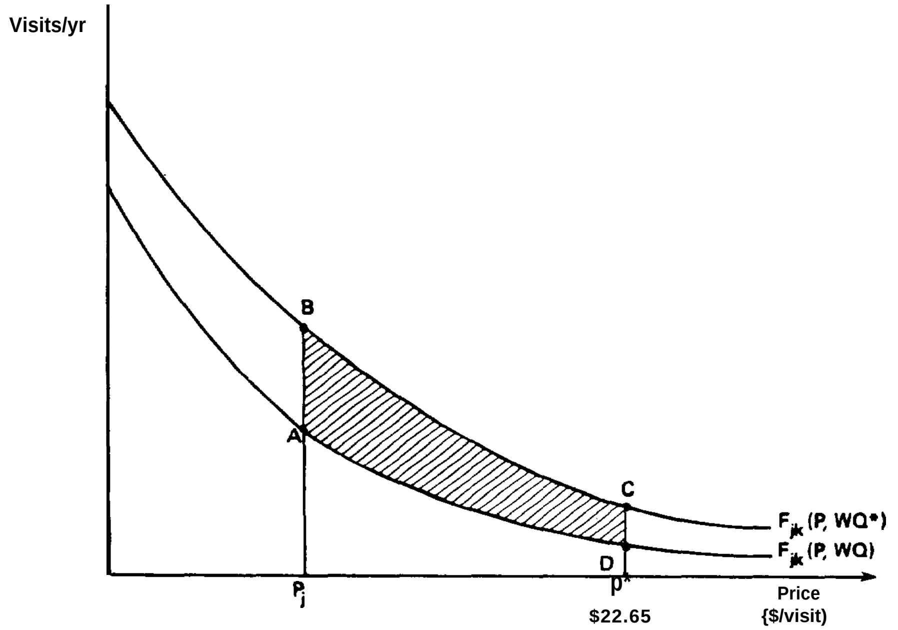

Figure 7-1. Measurement of consumer surplus increment due to water quality improvement (WQ to WQ*).

Table 7-16 details the dissolved oxygen levels associated with each of three use designations (see Vaughan in Mitchell and Carson [1981]) employed in the calculations rather than the actual water quality levels for the sites along the river. The reason for this approach follows from the key project objective--to compare benefit estimates based on the travel cost models with those based on the survey responses. All survey respondents were told that the water quality was consistent with boatable conditions. Thus, the corresponding value for dissolved oxygen was used as the base value for the estimates. Because the model requires a mean level of dissolved oxygen for the

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*This maximum travel cost is generally smaller than the maximum travel costs experienced by the Federal Estate Survey respondents used to estimate the generalized travel cost model. Indeed, it is less than the majority of the sample means of the FES travel costs (see Table 7-3).

Table 7-16. Dissolved Oxygen Levels for Recreation Activities[a]

Use designation	Assumed level of dissolved oxygen required
Boatable water conditions	45
Fishable water conditions	64
Swimmable water conditions	83

[a]These estimates for dissolved oxygen are based on Vaughan in Mitchell and Carson [1981].

summer recreation season, the means were assumed to correpond to each of the levels given in Table 7-16. The variance in monthly levels of dissolved oxygen was set at the sample mean for the sites used to estimate the model--8. 187--and was assumed to be unaffected by water quality changes.

Table 7-17 presents the mean values for the incremental benefits associated with three types of changes in water quality conditions:

- An assumed deterioration in water quality making it unavailable for boating or other recreation activities.
- An improvement in water quality from boatable conditions to fishable conditions.
- An improvement in water quality from boatable conditions to swimmable conditions.

All three of these changes were assumed to take place at all 13 of the Monongahela sites. The first was treated as the equivalent of losing the use of the recreation site completely. The benefit loss was measured as the consumer surplus associated with the site under boatable condition s-- PjADP* in Figure 7-1.

The remaining two scenarios correspond to different levels of the new demand functions for the water quality associated with fishable and swimmable conditions. Table 7-17 presents the mean consumer surplus increment for each of the three changes for our 94 user-site combinations. It also reports the range of values for the increment to consumer surplus. The mean benefits correspond to the increase in an "average" individual's willingness to pay over the recreation season. The average user in the survey used one or more Monongahela sites 7.22 times. Thus, the loss of the site completely translates to a loss of $7.39 per unit in 1977 dollars, or $11.46 in 1981 dollars, the date of the contingent valuation survey. *

*This adjustment used the consumer price index (CPI) for all commodities. Using a 1967 base, the 1977 CPI for all items was 181.5. In 1981 it closed the year at 281.5. See Economic Report of the President 1982, Council of Economic Advisors [1982].

Table 7-17. Mean and Range of Benefit Estimates for Water Quality Scenarios[a]

Water quality change	Mean[b]	Minimum value	Maximum value
Scenario (1) Loss of use of site under boatable conditions	$53.35 (7.39)	$0.00	$70.80
Scenario (2) Improvement of water quality from boatable to fishable conditions	$4.52 (0.63)	$0,00	$8.60
Scenario (3) Improvement of water quality from boatable to swimmable conditions	$9.49 (1.31)	$0.00	$18.30

[a]These calculations are in 1977 dollars, the year of the Federal Estate Survey.

[b]The numbers in parentheses below the overall increment report the corresponding consumer surplus increment on a per visit basis.

Because these benefits estimates are available for each of the 94 user/site combinations, the estimates in several classifications were also tabulated--by size of family income reported by the respondents and by the magnitude of their travel costs. The results for the consumer surplus loss due to loss of the use of the river for boating are given in Tables 7-18 and 7-19. The results for each of the two increments to water quality compared with income are given in Tables 7-20 and 7-21. It should be noted that the income levels are in 1981 dollars while the consumer surplus increment is in 1977 dollars. Scaling the latter by 1.55 will convert them to equivalent dollars. Since it was a simple multiple of the estimates and would not change the distributions, they were not converted for these tables.

These results indicate that it is possible to use a generalized form of the travel cost model to estimate the benefits from a water quality change. By using the recreation use patterns for a number of sites, it was possible to develop a general model that, in principle, is capable of being used to estimate the recreation benefits associated with water quality changes at any site Providing similar water-based recreation activities.

Table 7-18. Consumer Surplus Loss Due to Loss of Use of the Monongahela River by Survey Users' Income

Income (1981 dollars)	Consumers surplus loss (1977 dollars)[a]								
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	Total
0-5,000	--	--	1	2	--	4	3	--	10
5,000-10,000	--	--	--	--	--	2	7	2	11
10,000-15,000	--	--	--	--	--	2	6	--	8
15,000-20,000	--	1	1	2	--	3	11	--	18
20,000-25,000	1	1	1	--	1	1	1	--	6
25,000-30,000	1	--	2	2	3	8	6	--	22
30,000-35,000	--	--	--	3	--	2	2	--	7
35,000-40,000	--	--	--	--	--	2	1	--	3
40,000-45,000	--	--	--	1	1	--	1	--	3
45,000-50,000	--	--	--	--	--	3	1	--	4
50,000 and above	--	--	--	--	--	2	--	--	2
Total	2	2	5	10	5	29	39	2	94

[a]To convert to 1981 dollars multiply the endpoints of the benefit scale by 1.55.

Table 7-19. Consumer Surplus Loss Due to Loss of Use of the Monongahela River by Survey Users' Travel Cost

Travel cost (1 977 dollars)	Consumer surplus loss (1977 dollars)								
	o-1o	10-20	20-30	30-40	40-50	50-60	60-70	70-80	Total
0-5						19	39	2	60
5-10	-	-	-	2	5	10	-	-	17
10-15	-	-	4	8	-				12
15-20	-	2	1						3
20-25	2	-	-						2
Total	2	2	5	10	5	29	39	2	94

Table 7-20. Consumer Surplus Increments Due to Water Quality Improvement--Boatable to Fishable by Survey Users' Income

Income (1981 dollars)	Consumer surplus increment (1977 dollars)[a] o-1o	10-20	20-30	30-40	Total
0-5,000			3	7	10
5,000-10,000				11	11
10,000-15,000				8	8
15,000-20,000		2	16		18
20,000-25,000	1	2	3		6
25,000-30,000	1	3	18		22
30,000-35,000		4	3		7
35,000-40,000		3			3
40,000-45,000		3			3
45,000-50,000		4			4
50,000 and above	2				2
Total	4	21	43	26	94

[a]To convert to 1981 dollars multiply the endpoints of the benefit scale by 1.55.

Table 7-21. Consumer Surplus Increment Due to Water Quality Improvement--Boatable to Swimmable by Survey Users' Income

Income (1981 dollars)	Consumer surplus increment (1977 dollars)[a] 0-10	10-20	20-30	30-40	40-50	50-60	60-70	Total
0-5,000				1	1	2	6	10
5,000-10,000						2	9	11
10,000-15,000						8		8
15,000-20,000			1	3	6	8		18
20,000-25,000	1		2	1	2			6
25,000-30,000			3	18				22
30,000-35,000			3	4				7
35,000-40,000			3					3
40,000-45,000			3					3
45,000-50,000		4						4
50,000 and above	2							2
Total	3	5	15	27	9	20	15	94

[a]To convert to 1981 dollars, multiply the endpoints of the benefit scale by 1.55.

7.9 SUMMARY

The findings from the application of the travel cost approach are of equal, if not greater, importance. The research in this project developed a generalized travel cost model that predicts the recreation benefits of water quality improvements at a recreation site. Estimating the benefits for users of the Monongahela River, the travel cost model predicted benefits of $83 per year for a user if a decrease in water quality is avoided. Water quality improvements to swimmable water in the Monongahela were estimated at $15 per year (in 1981 dollars).

Two features of the generalized travel cost model are of particular importance. The model can be applied to predict the value of water quality improvements for a substantial range of sites, and it is especially relevant for a large number of water quality standards applications. Including the effect of key site features in addition to water quality--like access and facilities--and relying on data frequently available in the public domain makes the model a viable tool for future benefits applications.

CHAPTER 8

A COMPARISON OF THE ALTERNATIVE APPROACHES FOR ESTIMATING RECREATION AND RELATED BENEFITS

8.1 INTRODUCTION

One of the primary objectives of this research has been to compare available methods for measuring benefits of water quality improvement. Of course, the "true" value of benefits associated with a specific increment of water quality can never be known, and a comparison of measurement methods cannot be interpreted as a validation of any one of them. Nonetheless, it is important to recognize that contingent valuation methods for estimating the benefits of environmental quality improvements are viewed with considerable skepticism by many (if not most) economists. Presumably, these economists assume that individuals will experience difficulty in responding to valuation questions for nonpriced goods and that their responses will exhibit significant strategic bias. By contrast, indirect methods have been more favorably regarded by most economists, and this study's use of benefit estimates derived from one indirect method--the travel cost recreation demand model--as a benchmark for the contingent valuation estimates ref lects this perspective. Of course, it should be recognized that indirect and direct benefits measurement approaches can be distinguished according to the assumptions each makes and that a comparison of them reflects in part the plausibility of their assumptions as descriptions of real-world behavior and constraints.

To aid in the interpretation of the comparisons of benefit estimation approaches, this chapter highlights the specific features of the approaches and how they are applied in this study. The Monongahela River case study provides the basis for the evaluation of the approaches. The types of possible evaluations are bounded by its scope. More specifically, Section 8.2 of this chapter introduces the conceptual basis for a comparative evaluation of benefit estimation approaches. Following this discussion, Section 8.2 also relates the evaluation scheme used in this chapter to that used in earlier comparisons, including those of Knetsch and Davis [1966], Bishop and Heberletn [1979], and Brookshire et al. [1982]. Section 8.3 discusses the results of the comparison of approaches, including the findings of a numerical comparison of the mean estimates of the user and intrinsic components of benefits for specific water quality changes by methodology. This discussion is followed by pairwise comparisons of the contingent valuation and travel cost methods and of the contingent valuation and contingent ranking methods, Finally, Section 8.4 summarizes the findings and discusses their implications for the practical use of benefit measurement approaches.

8.2 THE CONCEPTUAL FRAMEWORK FOR A COMPARISON OF RECREATION BENEFIT ESTIMATION APPROACHES

8.2.1 Background

Improvements in water quality associated with water bodies that support recreation activities can lead to both user and intrinsic nonuse benefits. User benefits arise because water quality can be expected to affect the types of recreation activities at the site experiencing the changes. Individuals who wish to participate in activities made possible by the improvement will be able to, thus enhancing their levels of economic well-being. User benefit estimates of water quality improvements attempt to measure the magnitude of these changes in well-being. Intrinsic benefits, on the other hand, arise either because individuals are uncertain of their potential use of a site or because they experience enhanced utility merely from knowing of improved site conditions. The first recognition of the importance of intrinsic benefits has most often been associated with Krutilla's [1967] discussion of the rationale for public involvement in the management of natural environments. Intrinsic benefits have been identified under a variety of classification schemes to include option and existence values.

Because preceding chapters have presented detailed discussions of both user and intrinsic benefits, the definitions of each are not repeated here. Rather, this chapter considers the relationship between benefit estimation approaches and the two benefit classes. This relationship is important because it affects the types of comparisons that can be undertaken across approaches.

The measurement of the economic benefits of water quality improvement requires a mechanism for linking the water quality change to a consistent measure of benefits. As noted in Chapter 2, this linkage provides one basis for classifying methods used to measure benefits of a change in any environmental amenity not exchanged in an organized market. While Chapter 2 identifies several types of assumptions that provide these links, two classes of assumptions are especially relevant to the approaches considered in this project for benefit measurement.

The first relevant class of assumptions involves the use of the technical association between water quality and recreation site services. Use of a water body's recreation services involves a corresponding (and, indeed, simultaneous) use of the water quality at the site. Thus, the types of activities that can be undertaken at a particular site are affected by the site's water quality (a point explicitly made throughout the analysis in Chapters 4 through 7). Given both a behavioral model to describe how individuals allocate their resources and exogenous measures of their use of recreation sites with differing levels of water quality, this approach maintains that it may be possible to estimate individuals' willingness to pay for water quality indirectly. This recognition is, of courso, the basis for the approach used in the generalized travel cost model developed in Chapter 7.* However, more important for comparing measurement approaches

*This model assumes that each set of users for each of the sites included in our sample from the Federal Estate Survey acts as the "representative" individual would under the circumstances defined by the site's availability and the survey respondent's economic characteristics.

is that this approach--using "indirect" technical linkages between water quality and recreation site services --only measures user values.

The second. relevant class of assumptions, identified in Chapter 2 as institutional assumption S, explicitly recognizes that ideal markets would provide the benefit measures required for any good or service, providing the good could be exchanged in them. However, attempts to estimate the valuation of such environmental amenities as water quality face difficulties because ideal markets are not available. Thus, the contingent valuation approach--using "direct" institutional linkages --assumes that, if individuals are confronted with a hypothetical market (in the form a survey questionnaire) for these amenities, their responses will measure their true valuation of the resources (or amenities) involved. Thus, the contingent valuation approach assumes it is possible to mimic the outcomes of ideal markets by completely describing the conditions of exchange in a hypothetical market for the service to be valued. As a result, these methods assume that an individual's responses to the conditions presented in this hypothetical market will be equivalent to the actual responses that would be made if the exchanges took place in actual markets. Since the market is simply an Institution, a hypothetical market can be defined to suit any particular nonmarketed service and does not require that it actually be feasible to exchange the services described. Thus, contingent valuation methods can measure both user and intrinsic benefits.

in comparing the two classes of assumptions and the approaches for benefit measurement arising from them, it is important not to confuse the flexibility of the approaches using institutional restrictions with judgments that these approaches require less stringent assumption s.* Alternative approaches require different assumptions. Therefore, appraisals of the severity of one approach's assumptions relative to another's should be regarded as individual judgments, not necessarily as objective comparisons.

8.2.2 Research Design and Comparative Analysis

The research design of this project permits several types of comparisons. Chapters reporting each approach's estimates have discussed the first type--those within a benefit estimation framework. For example, the contingent valuation survey was designed to consider five different approaches for eliciting an individual's valuation of water quality changes. In four of these approaches, only the valuation question differed:

- A direction question
- A question using a payment card

*The classification scheme for benefit estimation methods given by Schulze, d'Arge, and Brookshire [1981], pp. 154-155, is somewhat misleading in that it implies the contingent valuation approach has the least a priori assumptions. While this is true as a description of the assumptions concerning constraints to actual behavior, it ignores the implicit assumption that responses to hypothetical institutions will provide a good guide to the responses made to the actual institutional arrangements implied by their "constructed" markets.

- The conventional iterative bidding framework with a $25 starting point

- The conventional iterative bidding framework with a $125 starting point.

Each questioning format was applied to an approximately equal proportion of the sample and provides independent estimates of an individual's valuation of the specified water quality changes. Because the design of the questions elicited the individual's option price and user values, comparisons of these questioning formats were undertaken for the estimates of option price, user value, and option value with the results described in detail in Chapters 4 and 5.

This chapter focuses on comparisons between benefit estimates across methodologies --e.g. , travel cost vs. contingent valuation. These comparisons will also involve the effect of question format, but the effect of format may differ from the within methodologies comparison because the standards for the comparisons are different. Equally important, the comparisons across methods cannot consider each method's performance in measuring combined user plus intrinsic benefit (i.e. , option price) as well as their separate estimates (e. g., in form of option value). The travel cost method measures only user value, and the contingent ranking only a composite of the two.

The specific details of the within method comparison involved two types of evaluations:

- Statistical tests for the differences in means between all pairs of question formats for the full sample and for users and nonusers of the Monongahela River.

- Multivariate regression analysis, including dummy variables for the question formats along with other prospective determinants of the relevant dependent variables.

The option price results exhibit the most differences among question formats, with some evidence of a starting point bias. The regression models also exhibit the most cases of significant effects for the question format variables in this case. This finding contrasts with several (but not all) of the past contingent valuation studies. * With the option value estimates there is also some evidence of starting point bias, but these findings are not as pronounced as in the analysis of the option price estimates. These differences are not necessarily surprising since only the first stage of the individual's response (i .e. , the option price) had distinct questioning formats. Thereafter, the questions calling for separation of the option price into components (i. e., user values) were (by practical necessity) direct questions.

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*The Schulze, d'Arge, and Brookshire [1981] summary concludes, based on an analysis of several contingent valuation experiments, that starting point bias is not a serious problem. Our results do not conform to this conclusion and indicate that the prescreening of data used to eliminate inconsistent observations may affect their conclusions. Of course, it should also be emphasized that our results relate only to a single experiment.

Finally, the results are quite sensitive to the screening of observations judged to be refusal to participate in, or Inconsistent with, the contingent valuation framework. As noted in Chapter 4, while procedures used to identify these observations are based on a statistical index of the influence of each individual observation (and are therefore capable of replication), the effects of specific socioeconomic characteristics of the survey respondents cannot be distinguished from the question format (see Table 4-8 in Chapter 4). Thus, the results for starting point bias and for other pairs of question formats (iterative bidding with $125 starting point) would have been more pronounced with the inclusion of the observations judged to be inconsistent with the contingent valuation framework.

Comparisons across approaches are limited because the methods do not uniformly measure the same components of the benefits associated with a water quality improvement. As we noted earlier, the contingent valuation method design measures both user and intrinsic benefits and permits these estimates to be separated. By contrast, the travel cost and contingent ranking methods are more limited. The travel cost approach measures only user values (i.e. ordinary consumer surplus). The contingent ranking design measures option price but does not divide the estimates into the user value and option value. Therefore, comparisons here are limited to examining the relationship between the user value estimates of the contingent valuation and travel cost approaches and the option price estimates for contingent valuation and contingent ran king.*

The comparison of the estimated user values derived using the contingent valuation approach (with all four question formats) and the consumer surplus estimates derived from the generalized travel cost model is the most interesting comparison. It provides an extension to the recent work of Brookshire et al. [1982] for the valuation of air quality using hedonic property value and contingent valuation methods.

Using a subset of the survey respondents who visited specific Monongahela River sites to derive consumer surplus estimates from the generalized travel cost model (presented in Chapter 7) allowed a matching of each respondent's expressed user value for a comparable water quality change with the values predicted from the travel cost model. This comparison of the travel cost and contingent valuation methods can be made for each user in this survey, in contrast to the Brookshire et al. [1982] analysis.† Thus, both the mean estimates derived from the two approaches and the association in the estimates can be compared across individual users.

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*For the sake of simplicity in the use of terms in this chapter contingent valuation is used to refer to the four question formats in the contingent valuation survey. While contingent ranking is a subset of contingent valuation (and this distinction was made in Chapter 1), the easier terminology of contingent ranking vs. contingent valuation is used in this comparison chapter.

†This is one of the aspects of our extension over this work. A second involves replacing the broad bounds for contingent valuation estimates with a potentially more restrictive upper threshold.

Several features limit the ability to compare the estimates derived from the travel cost and contingent valuation methods. The simplest of these features is different dollar values in each method because the travel cost model was developed with 1977 dollars and the contingent valuation estimates was developed with 1981 dollars. Using the consumer price index, an adjustment can approximately account for this difference. A more important reason for differences stems from what is being measured. The user values derived using contingent valuation methods estimate an individual's expected willingness to pay or compensating surplus (for improvements in water quality), while the generalized travel cost model estimates ordinary consumer surplus. A long literature on the theoretical foundations of consumer surplus estimates has suggested that there are good reasons why these two measures should diverge. * However, for price (Willig [1976]) and quantity (Randall and Stoll [1980]) changes, the difference between the two measures can be bounded under specific conditions (see Chapter 2 for a brief review).

At first, the comparison of welfare measures in this project might seem to involve a case that falls outside the scope of the bounds, because it involves a change in water quality rather than a price or quantity change. Fortunately, this conclusion is premature. One of the assumptions used to develop the generalized travel cost model--that water quality augments the effect of a recreation site's services in the production of recreation activities (see Equations (7.11) and (7.12) in Chapter 7)--implies that a water quality change can be translated into an equivalent change in either the quantity of a site's services or in the "effective" price of using the site (see Equations (7.12) and (7.13), respectively). † Therefore, for changes in water quality

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*See Just, Hueth, and Schmitz [1982] for further discussion.

_#'in general terms the consumer surplus increment due to a water quality change, w, with a demand function Q = F(P, w) (P = price, Q = quantity) is given as

$$Cs_i = \int_{P_i}^{p^*} F(p_i, w_2)dp - \int_{P_i}^{P^*} F(p_i, w_1)dp \quad ,$$

where

Cs_i = consumer surplus for individual facing price Pi

p^* = price at which the quantity demanded would be zero

w_2 = improved level of water quality

w_1 = existing level of water quality.

The form of the household production technology assumed in the development of our travel cost model implies that a change in water quality can be considered equivalent to a change in the quantity of or price of a site's services. This implies that the change from w_1 to w_2 can be treated as equivalent to some change in the price of a site's services from $P(w_1)$ to $P(w_2)$.

that translate into relatively small price (quantity) changes, the Willig (Randall and Stoll) bounds can be applied to judge the relationship between Marshallian consumer surplus and the willingness to pay for a water quality change.

From a practical perspective, one might assume that the discrepancies between the Marshal lian consumer surplus and the willingness to pay for a water quality change associated with recreation water sites would be small. Most households' expenditures on water-based recreation activities would be a very small fraction of their income. This judgment is also supported by the estimated travel cost demands developed for this study in that they imply income is not a significant determinant of the demand for the services of water-based sites comparable to sites on the Monongahela River. Thus, the difference between the willingness to pay and the consumer surplus for a comparable change in water quality can be expected to be less than 5 percent. * The evidence necessary for judging the implications of income for survey respondents who were users of the Monongahela River can be derived using the same type of information required by the travel cost model. † That is, because individual estimates of the ordinary consumer surplus require travel cost and income information, these variables were combined with the respondents' reported use patterns for the Monongahela sites, thus treating all 13 sites as if they shared a common demand function, even though the generalized travel cost model does not require this assumption. These data permit the estimation of a travel cost model for the Monongahela in its current state. The results are given in Equation (8.1) below:

$$\ln V = \underset{(3.153)}{0.7983} - \underset{(-0.785)}{0.0195}\,(T+M)\text{ cost} + \underset{(1.636)}{0.000015}\text{ income} \tag{8.1}$$

$$R^2 = 0.032$$

The numbers in parentheses are the t-ratios for the null hypothesis of no association. These results indicate that income is not a significant determinant of user trips to the Monongahela sites. Therefore, these findings would be consistent with judgments based on the generalized travel cost model, and willingness to pay would be expected to be less than the Marshallian consumer surplus for water quality improvements (the equivalent, in the generalized

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*See Freeman [1979a] or Just, Hueth, and Schmitz [1982] for a complete discussion of the implications of the Willig [1976] bounds for applied benefit analysis.

†The generalized travel cost model assumes that a water quality change can be translated into either an equivalent price or quantity change. Thus, the site demand equation is the relevant basis for judging income responsiveness. Survey responses for compensating surplus (referred to as user value in Chapter 5) are expected to provide equivalent results if these two sets of information provide consistent descriptions of the individuals' demand characteristics. An examination of the role of income in the user value equations confirms this a priori expectation. The coefficients estimated for income are never judged to be statistically significant determinants of user values.

travel cost model, of price decreases for the site's services or quantity increases). However, these estimates of income effects imply that the difference between willingness to pay and consumer surplus should be small.

These results can also be compared with the predicted demands for each of the 13 Monongahela sites based on the generalized travel cost model and the characteristics of each of these sites. Of course, this comparison cannot be treated as an evaluation. The estimates given in Equation (8.1) are pooled across sites and assume the demand parameters are invariant with respect to site attributes. Nonetheless, the comparison may serve to identify whether the implied demand features are completely incompatible with these crude estimates available as a byproduct of the survey data. The focus is on the parameters of greatest influence for estimates of consumer surplus change in response to a water quality change. Table 8-1 reports these predicted parameters for the intercept and coefficient of (T+M) cost for each of the 13 sites under the assumption of boatable water quality. The absolute magnitude of the price coefficient is in all cases smaller than any estimates based on the survey, but they are reasonably close to the survey estimates. The intercept predictions are substantially larger than the survey estimates.

The second comparison across benefit methodologies involves the contingent valuation and contingent ranking approaches. Because all survey respondents were asked one of the four types of contingent valuation questions and the contingent ranking, the estimates from these approaches are not independent estimates of the option prices for water quality changes. Indeed, it is possible that an individual's responses to the contingent valuation questions, which preceded the ranking questions on the survey instrument, influenced the rankings. Therefore, this comparison reflects both the effects of the methods used to estimate benefits and an individual's consistency in responding to comparable water quality increments in different formats.

Table 8-1. Predicted Demand Parameters for Monongahela Sites

Site	Intercept	Coefficient for T+M cost
Pittsburgh area	1.323	-0.0133
Confluence of the Youghiogheny and Monongahela Rivers	1.317	-0.0132
Elrama	1.317	-0.0132
Town of Monongahela	1.306	-0.0131
Donora and Webster	1.323	-0.0133
Near Charleroi	1.317	-0.0132
California and Brownsville	1.308	-0.0131
Maxwell Lock and Dam	1.311	-0.0130
Point Marion	1.323	-0.0733
Morgantown	1.404	-0.0140
Fairmont	1.449	-0.0144
9th Street Bridge	1.323	-0.0133
Cooper's Rock	1.323	-0.0133

8.2.3 Past Comparisons of Benefit Estimation Methods

Comparisons of the results of benefit estimation methodologies within the context of a common problem have been quite limited. The first such comparision was undertaken by Knetsch and Davis [1966] and involved a bidding game version of what is now commonly referred to as contingent valuation and a form of the travel cost model. The survey was based on a sample of 185 users of a forest recreation area in northern Maine. With the iterative bidding game, respondents were asked their willingness to pay (as increased cost to visit the area). A similar format was used to elicit willingness to drive to the area. Individuals were also asked the actual distance they traveled to the site.

Knetsch and Davis compared three approaches for estimating the aggregate benefits from the site. The first used a willingness-to-pay equation based on the survey results to estimate a willingness-to-pay schedule for the user population in the area surrounding the site. The two sets of distance measures were each valued at $.05 per mile and used to derive aggregate schedules for the user population. The aggregate benefit estimates derived for each approach provided the basis for comparing the methods:.

Contingent valuation	$71,461
Willingness to drive	$63,690
Travel cost	$69,450

Because the contingent valuation approach measures willingness to pay and travel cost measures the ordinary consumer surplus, the latter would be expected to exceed the former at an individual level, However, it is difficult to gauge the expected nature of the differences between the two methods for these calculations because they involve the aggregate schedule over all individuals and relate to changes in the price of the site comparable to a loss of its availability for this population. As Bockstael and McConnell [1980] observe, the Willig bounds may not hold where the analysis involves the removal of the site. They observed that:

> it is difficult to find single valued functions, x = f(p, m) [where x = quantity demanded, p = price and m = income], decreasing in a and increasing in m, such that:
>
> 1. $\frac{m \frac{\partial x}{\partial m}}{x}$ is finite for all values of p and
>
> 2. the function f(p, m) must tend to zero rapidly enough with increases in p that the integral of f(p, m) will be hounded when evaluted as p goes to infinity. (p. 61)

Because Knetch and Davis do not present demand equation estimates with their travel cost findings, it is difficult to evaluate the relationship between their willingness to pay and consumer surplus estimates on an individual basis. Their benefit estimates based on the willingness-to-travel responses are diffi-

Table 8-2. Bishop-Heberlein Comparative
Results for Benefit Approaches[a]

Method	Average benefit estimate per permit
I. Actual case offers	$63
II. Hypothetical responses	
(a) willingness to sell	$101
(b) willingness to pay	$21
III. Travel cost ordinary consumer surplus (variation associated with valuation of travel time from 0 to ½ median income rate)	$11 to $45

[a]These estimates are taken from Table 1 in Bishop and Heberlein [1979], p. 929.

cult to interpret within the conventional welfare economics framework and thus cannot be directly associated with either of the other benefit estimates. Thus, while this study offered the first evaluation of benefit estimation approaches, it did not permit a detailed comparative analysis of them.

The second comparative analysis was conducted by Bishop and Heberlein [1979] and was primarily intended to evaluate the relationship between hypothetical and actual responses to willingness-to-sell questions. * Their analysis was conducted using goose hunting permits for hunters in Wisconsin. Three samples of hunters were used in their analysis. The first sample received actual cash offers for their permits (ranging from $1 to $200); a second sample received questionnaires asking the individual's willingness to pay for (and willingness to sell) their permits; and a third sample received questionnaires designed to permit the estimation of a traval cost demand equation. Table 8-2 summarizes the Bishop and Heberlein estimates per permit for each of the ap-

*Bishop and Heberlein describe a number of potential biases that might distinguish hypothetical and actual responses to willingness-to-pay questions. Some of these problems conform to the definitions used in the papers reporting contingent valuation survey results. The most directly comparable case is strategic bias. However, the Bishop-Heberlein approach does not attempt to induce differential responses from individuals, by giving them, for example, different information about the uses that will be made of their bids to hypothetical changes. This approach has been the most common method for investigating the potential for strategic bias in the contingent valuation experiments (see Schulze, d'Arge and Brookshire [1981]). Rather, their compari - of actual and hypothetical responses will reflect a composite of any such biases due to the "framing" of their hypothetical survey instrument and to the distinction between hypothetical and real conditions.

proaches considered. Their findings suggest that hypothetical willingness-to-sell estimates overstate actual responses. Moreover, Bishop and Heberlein argue that hypothetical willingness to pay and ordinary consumer surplus estimated with the travel cost demand model understate the actual willingness-to-sell by more than the Willig bounds would imply.

The Bishop and Heberlein results, while limited to a single experiment, have potentially important implications for the relationship between hypothetical and actual estimates of willingness to sell. They do not offer as much guidance on the comparative properties of the benefit estimation methodologies themselves. The authors' benefit estimates made with the travel cost model can be interpreted (for one value for the opportunity cost of travel time) as quite close to the hypothetical willingness to pay. However, because the selection of an opportunity cost for travel time is treated as judgmental, more specific conclusions are not possible. Finally, the Bishop-Heberlein research design (i.e. , the selection of independent samples for the hypothetical and travel cost surveys) did not permit comparison of the hypothetical willingness to pay and ordinary consumer surplus on an individual basis.

Most recently, Brookshire et al. [1982] provided comparative analysis of benefit estimation methods, maintaining it as a validation analysis of the contingent valuation methodology. As observed earlier, this reflects the interpretation given to contingent valuation versus indirect benefit estimation methods by many economists and is somewhat unfortunate. Each of the methods involved in the Brookshire et al. [1982] comparative evaluation is based on <u>different</u> assumptions concerning the economic behavior of households and the role of environmental amenities (i.e. , air quality) in their decisionmaking. Neither method provides the "true" benefit estimates for air quality improvements.

The Brookshire et al. [1982] analysis compares a hedonic property value model to a contingent valuation approach for measuring the willingness to pay for reductions in air pollution. The authors interpret the hedonic model as providing an upper bound for willingness to pay and argue that the assumptions of the model are approximately satisfied for the Los Angeles area. At issue in their comparison, however, is whether direct questions can be believed. They demonstrate if each method conforms to its respective assumptions, the annual rent differential for pollution should exceed estimates of the annual willingness to pay.

Using paired areas in Los Angeles selected to be homogeneous with respect to socioeconomic, housing, and community characteristics but with variation in air pollution, Brookshire et al . [1982] tested two hypotheses:

- The rent differential for pollution should exceed estimates of annual willingness to pay.
- Willingness to pay estimated from the contingent valuation survey bids are different from zero.

The design for the test used a hedonic property model that was estimated with sales of single-family houses in these areas and the contingent valuation experiment conducted with households selected from the same areas. Overall, the Brookshire et al. [1982] findings supported the presence of positive bids for air pollution reductions in all areas, as well as the ranking of rent differentials over bids in 10 of the 11 communities. Thus, the Brookshire et al. [1982] analysis provides the first evidence that benefit estimates derived from survey procedures fall within the theoretical bounds for willingness to pay. Nonetheless, the comparison is based on average responses within the selected communities and not estimates at an individual level.

In summary, past efforts (especially those of Bishop and Heberlein [1979] and Brookshire et al. [1982]) directed toward comparative evaluations of benefit methodologies are complementary to those available from the comparative analysis of this study. The comparison of the travel cost and contingent valuation is especially important because of the ability to compare benefits estimated for the same users.

8.3 A COMPARATIVE EVALUATION OF THE CONTINGENT VALUATION, TRAVEL COST, AND CONTINGENT RANKING BENEFIT ESTIMATION METHODS

Mean estimates are provided in Table 8-3 for each component of the benefits associated with three water quality changes:

- Deterioration in water quality leading to the loss of the recreational use of the area for water-based activities
- Improvement in water quality from its present state (beatable conditions) to fishable conditions
- Improvement from beatable to swimmable conditions.

The estimates include the option price and its components--user value and option value. These results are based on different subsets of the Monongahela survey respondents and are measured in 1981 dollars. The contingent valuation estimates are based on the full sample, excluding protest bids and those respondents identified as outliers in the survey (i.e. , using the Belsley, Kuh, and Welsch [1980] regression diagnostics, as detailed in Chapter 4). The travel cost estimates were derived for the survey respondents who were users of sites along the Monongahela River. * Finally, the contingent ranking estimates relate to those survey respondents who reported complete ranking information and income. Thus, this group includes some individuals who were judged outliers in the contingent valuation survey.

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*The travel cost results include all survey respondents who were users of sites along the Monongahela River, whether or not they were identified as protest bids or Belsley, Kuh, and Welsch [1980] outliers. Table C-18 in Appendix C provides the regression comparisons of contingent valuation and travel cost estimates with these individuals deleted from the sample. The deletion of these respondents does change any of our conclusions.

Table 8-3. A Comparison of Benefit Estimates for Water Quality Improvements (1981 Dollars)

Methodology y	AWQ = Loss of use			AWQ = Boatable to fishable			AWQ = Boatable to swimmable		
	Option price	. User value[a]	Option value	Option price	User value[a]	Option value	Option price	User value[a]	Option value
I. Contingent valuation									
Direct question	24.55	6.57 (19.71)	17.98	17.65	7.06 (21.18)	10.59	31.20	13.61 (31.18)	20.80
Payment card	51.00	6.20 (19.71)	44.82	29.26	9.72 (30.88)	19.54	42.87	15.92 (51.18)	26.76
Iterative bidding ($25)	28.97	2.16 (6.58)	26.81	15.95	1.38 (4.21)	14.57	25.09	3.12 (10.53)	21.64
Iterative bidding ($125)	57.40	12.08 (36.25)	45.31	36.88	6.77 (20.31)	30.10	60.20	13.43 (48.75)	43.96
II. Contingent ranking[c]									
Ordered logit				60.03	-		108.06		
Ordered normal				62.12	-	-	111.81		
III. Generalized travel cost[d]		82.65	-		7.01	-		14.71	-

[a]The numbers in parentheses below the estimated user values report average user values for users only. Since nonusers have a zero user value, the combined mean understates user values.

[b]These estimates are for the combined sample including users and nonusers. It excludes protest bids and outliers detected using the Belsley, Kuh, and Welsch regression diagnostics.

Cthese estimates are for the sample of respondents with usable ranks and reported family income. Estimates evaluated at the intermediate payment level.

[d]These estimates are for survey respondents using Monongahela sites and have been converted to 1981 dollars using the consumer price index.

Table 8-3 clearly illustrates the pairwise comparisons possible with these three methods. Because contingent valuation provides the most complete set of estimates, it can be compared to both of the other methods for several components of the benefits from a water quality change.

Simple comparisons of the means in Table 8-3 indicate that the relationship between the methods depends on the type of change in water quality being considered. For example, in the case of user values, contingent valuation estimates would be expected to be less than the travel cost estimates of ordinary consumer surplus for improvements in water quality. However, based on the arguments developed in the previous section of this chapter, these differences would likely be slight. This relationship does not seem to have been upheld for improvements in water quality when the mean willingness to pay for users (reported in parentheses in Table 8-3) is compared with the ordinary consumer surplus increments. Three of the four contingent valuation approaches contrast with this expectation for both of the water changes. Only the mean for the iterative bidding format with the $25 starting point is less than the ordinary consumer surplus estimate. Moreover, the differences in some cases are greater than the theoretical arguments would have implied. Because the largest of these estimates is not associated with the iterative bidding framework with a $125 starting point, the discrepancy cannot be attributed to starting point bias. These comparisons are not statistical tests, and the contingent valuation estimates exhibit considerable variability. Indeed, the travel cost estimates do fall, for both levels of improvement in water quality, in the range of estimates provided by the various approaches to contingent valuation.

The comparison between the means for the contingent valuation and travel cost estimates is consistent with theoretical expectations for a reduction in water quality that leads to the loss of the area. In this case, the ordinary consumer surplus is more than twice the size of the largest of the contingent valuation estimates. The size of this difference was somewhat unexpected based on the simple theoretical arguments discussed earlier. Accordingly, it serves to highlight the potential importance of each methodology's assumptions in comparing their respective estimates. One explanation of this large difference arises from an assumption implicit in the travel cost model. The data required that the travel cost demand model ignore the effects of substitute sites as determinants of the demand for any one site's services. However, judging the potential effects of this limitation on the estimates from the generalized travel cost model are difficult. The model developed in Chapter 7 assumes that each individual considered only site attributes in judging the degree of substitutability between sites. Indeed, it was based on the assumption that all sites' services could be measured on a common scale reflecting these attributes. To the extent this assumption is either inappropriate or a relatively weak approximation of each individual's perceptions of the relationship between sites, there will be two types of effects on the demand model. First, the omission of variables reflecting the prospective role of these substitution effects in any site's demand function is a specification error that may bias estimates of the other variables' effects on demand. Equally important, the differential accessibility of substitute sites of comparable or higher quality will tend to mitigate the impact of any deterioration in water quality at a given duce the incremental benefits from improvements. Thus, it is difficult to predict with certainty the impacts of the treatment of the role of substitutes for benefit estimates derived from the generalized travel cost model.

Nonetheless, it does seem reasonable to expect that the use of a model that ignores the role of substitutes may not seriously affect the benefit estimates associated with the increments to water quality that serve to enhance the activities supported by a recreation site. By contrast, this judgment is not as readily accepted for the loss of a site. In this case, the presence of substitute facilities can be expected to mitigate the loss. Thus, the generalized travel cost model (which ignores the role of substitute sites) may overestimate the consumer surplus associated with the loss of the use of the Monongahela River for boating recreation.

The second comparison that can be made is between the contingent valuation and contingent ranking estimates of the option price. Regardless of the technique used to estimate the random utility function, the contingent ranking approximation of option price consistently exceeds the contingent valuation estimates. Because both methods focus on the same benefit concept, the explanations for it must arise from the assumptions of each approach. The approximations used to derive the contingent ranking benefit estimates may be especially important to such an explanation. * However, in the final analysis, there is little additional information that can be gleaned from a comparison of means.

The most interesting comparisons of contingent valuation and travel cost estimates are based on the subsample of users; the most interesting comparisons of contingent valuation and contingent ranking are based on the subsample of respondents with complete information on the ranking of water quality and payment alternatives. Both sets of comparisons use individual benefit estimates.

The comparison of contingent valuation and travel cost estimates of user values is presented in Table 8-4. The objective of this comparison is to judge how the benefit measures derived using the two approaches compared across individuals. Accordingly, a common set of procedures was used to evaluate the accuracy of a set of forecasts (see Theil [1961], pp. 31-33, for discussion of this type of application). In this comparison, the contingent valuation measure of user value was regressed on the travel cost estimate. Because this comparison may be affected by the question format used with the contingent valuation approach, qualitative variables for three of the four modes were also included as determinants of the level of the contingent valuation estimates.

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*This benefit measure is described as approximate because of its definition as an increment to the payment required to hold an individual's utility constant in the presence of a water quality improvement and because of the theoretical inconsistency in the functions 'form used for the indirect utility function (see Chapter 6 for details).

TABLE 8-4

Table 8-4. A Comparison of Contingent Valuation and Generalized Travel Cost Benefit Estimates[a]

	AWQ = Loss of area		AWQ = Boatable to fishable		AWQ = Boatable to swimmable	
	Model	Test[b]	Model	Test[b]	Model	Test[b]
Independent variable						
Intercept	21.862 (1.371)		33.985 (1.900)		59.574 (2.017)	
Travel cost benefit estimate	.328 (1.169)	-4.357	-3.670 (-1.204)	-1.712	-2.713 (-1.141)	-1.793
Qualitative variables						
Payment card	-32.640 (-2.551)	-	51.757 (2.639)		77.010 (2.359)	
Direct question	-14.602 (-1.270)		12.957 (0.748)		21.001 (0.729)	
Iterative bid ($25)	-31.817 (-2.549)	-	-11.244 (-0.595)		-21.819 (-0.693)	
R^2	.099		.120		.107	
n	93		93		93	
F	2.42 (0.05)[c]		3.00 (0.02)[c]		2.62 (0.04)[c]	

[a]The numbers in parentheses below the estimated coefficients are t-ratios for the null hypothesis of no association.

[b]This column reports the t-ratio for the hypothesis that the coefficient for the travel cost variable was 1,55. The travel cost model measures consumer surplus in 1977 dollars. The contingent valuation experiments were conducted in 1981. Using the consumer price index to adjust the travel cost benefit estimates to 1981 dollars would require multiplying each estimate by 1.55. Since the estimated regression coefficients (and standard errors) will correspondingly adjust to reflect this scale change, a test of the null hypothesis that the coefficient of travel cost was equal to unity is equivalent to a test that is equal to 1.55 when the travel cost benefit estimates are measured in 1977 dollars and user values estimates (the dependent variable) are in 1981 dollars.

[c]This number in parentheses below the reported F-statistic is the level of significance for rejection of the null hypothesis of no association between the dependent and independent variables.

The analysis was considered for each of three water quality changes:

- Deterioration in water quality leading to the loss of the areas
- Improvement in water quality from its present state (boatable conditions) to fishable conditions
- Improvement from boatable to swimmable conditions.

The results generally reinforce the earlier judgments from comparing the estimated mean user values from each method. Theory suggests contingent valuation estimates would be less than the ordinary consumer surplus estimates from the travel cost model for water quality improvements, but these differences should be rather small. This a priori expectation can be evaluated by testing the null hypothesis that the intercept for the model is zero. Equally important, if the two methods provide comparable estimates of user values that closely approximate each individual's willingness to pay, the slope parameter for the travle cost consumer surplus would be expected to be insignificantly different from unity. Finally, if the question mode does not influence the responses derived with contingent valuation surveys, the dummy variables for question mode would likely not be significantly different from zero.

More formally, it has been maintained that the contingent valuation estimates of an individual's willingness to pay for water quality changes "a", CV_a, will be approximately a homogeneous function of the conditional expectation for the Marshal lian consumer surplus, MS_a (i.e. , the predicted consumer surplus from the generalized travel cost model for water quality change "a"). This function will exhibit a slope of unity. This model is to be distinguished from an errors-in-variables framework in which it would be maintained that "either benefit measure describes what it is purported to measure. Under this study's interpretation, the travel cost estimates of consumer surplus play the same role as the estimates of the conditional expectation of endogenous variables in a deterministic simulation of an econometric model (see Howrey and Kelejian [1969] and Aigner [1972]). Hence, large sample evaluations of the parameters in the model --testing the hypotheses of zero intercept and unitary slope--do provide some guidance as to the relationship between methods.

The results provide some interesting insights for each of these issues. considering the relationship between the level of the contingent valuation estimates and those of the travel cost model, there is some evidence for a difference between the levels of the two approaches for improvements in water quality that contradicts a priori expectations. The intercepts for the equations associated with both levels of water quality increments (i.e. , from boatable to fishable and from boatable to swimmable) are positive and statistically significant at the 90-percent significance level. However, there are at least two reasons for interpreting these results cautiously. The generalized travel cost model does not permit the effect of the intercept to be distinguished from at least one of the questioning formats. In the models reported in Table 8-4, the intercept reflects the effects of the iterative bidding format with a $125 starting point. Testing whether the sum of the intercept and any one of the coefficients for other models was nonzero would simply change the format included. Ignoring the effects of question format by eliminating these variables from the models simply reinforces the conclusion that the intercept for these cases is positive and significantly different from zero.

Thus, there is some evidence to support the conclusion that contingent valuation methods may overstate willingness to pay for water quality improvements. It is not unambiguous evidence, because the tests are based on large sample behavior and have been applied using the conventional t-distributions. These findings are not necessarily at variance with the Brookshire et al. [1982] conclusions. Their evaluation concluded that contingent valuation estimates fall within the bounds which can be established by theory. It does not indicate how close the estimates fall to the "true" value of individual willingness to pay. An appraisal suggests that, for increments (improvements) to water quality, contingent valuation estimates may well overstate the user benefits.

The conclusion for reductions in water quality that would be associated with the loss of the area is less clearcut. In this case, the contingent valuation estimates are less than ordinary consumer surplus, as theory would imply. However, they are substantially less, and the reasons may be associated with the travel cost model and not the survey approach to benefit estimation. Based on the association between estimates across individuals, there is support for the conclusion that the travel cost model overstates the benefits associated with avoiding the loss of the area. The slope coefficient is significantly different from theoretical expectations. Since the travel cost benefits are measured in 1977 dollars, the correct null hypothesis for the slope coefficient when 1977 dollars are not converted to 1981 is that the coefficient equals the adjustment factor (in this case, 1.55).* For improvements in water quality, the coefficients are numerically large and have an incorrect sign, but they are not significantly different from 1.55.

Thus, for changes in water quality, the models do seem to move together (with the contingent valuation potentially exhibiting a positive bias in estimating willingness to pay). The performance of the contingent valuation method does appear to depend on the mode of questioning used--with the clearest distinctions found between the payment card and iterative bid with a $125 starting point. While the explanatory power of the model is not high, reflecting the variability in the contingent valuation responses for user values, the null hypothesis of no association between these measures of user values (along with the qualitative variables) is clearly rejected at high levels of significance based on the F-statistics, reported at the bottom of the table.

The second individual level comparison involves estimates of the option price using contingent valuation and contingent ranking methods. Table 8-5 reports a comparable set of regression models comparing these estimates. However, two further distinctions are possible in this comparison. Given the functional form specified for the indirect utility function, the contingent ranking estimate of option price will depend on the level of the payment suggested to the individual. Consequently, the benefits were calculated at all three levels and the regressions were replicated for each of them. In addition, two econometric estimators were used with the contingent ranking models so that each was also considered. Table 8-5 reports all of the comparisons for two increments in water quality--improvements from boatable to fishable and from boatable to swimmable.”

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*Scaling all the values of an independent variable by k will scale the ordinary least-squares estimate of the parameter for this variable (in a linear model) and its estimated standard error by $\frac{1}{k}$. Thus, to test the null hypothesis of unity for such a parameter would imply using

$$\frac{\frac{\hat{b}}{k} - 1}{\frac{\hat{\sigma}_b}{k}} \text{ or } \frac{\hat{b} - k}{\hat{\sigma}_b} .$$

Table 8-5. A Comparison of Contingent Valuation and Contingent Ranking Benefit Estimates

	ΔWQ = Beatable to fishable						AWQ = Boatble to swimmable					
	Payment = $50		Payment = $100		Payment = $175		Payment = $50		Payment = $100		Payment = $175	
Independent variable	Model	Test	Model	Test	Model	Test	Model	Test	Model	Test	Model	Test
ORDERED LOGIT												
Intercept	-20.141 (-1.095)		-23.647 (-1.223)		-23.927 (-1.227)		-25.661 (-0.795)		-30.734 (-0.905)		-31.032 (-0.906)	
A Payment	1.209 (4.279)	0.741	1.315 (4.237)	1.016	1.330 (4.214)	1.048	1.081 (3.925)	0.283	1.170 (3.867)	0.561	1.183 (3.841)	0.594
Qualitative variables												
Payment card	-22.486 (-2.424)		-22.070 (-2.360)	-	-21.960 (-2.367)		-46.842 (-2.877)		-46.145 (-2.834)		-45.961 (-2.822)	
Direct question	-35.267 (-3.751)		-34.595 (-3.683)		-34.425 (-3.665)		-55.327 (-3.353)		-54.215 (-3.288)		-53.935 (-3.270)	
Iterative bidding ($25)	-38.045 (-4.067)		-37.562 (-4.015)		-37.446 (-4.001)		-68.611 (-4.178)		-67.817 (-4.128)		-67.626 (-4.115)	
R^2	.165		.164		.163		.153		.151		.150	
n	184		184		184		184		184		184	
F	8.67 (0.0001)		8.77 (0.0001)		8.72 (0.0001		8.06 (0.0001)		7.94 (0.0001)		7.88 (0.0001)	
ORDERED NORMAL												
Intercept	-13.467 (-0.839)		-15.565 (-0.940)		-15.832 (-0.951)		-15.153 (-0.537)		-18.212 (-0.626)		-18.559 (-0.634)	
A Payment	1.073 (4.554)	0.309	1.140 (4.528)	0.554	1.151 (4.516)	0.592	.962 (4.182)	-0.165	1.018 (4.146)	0.073	1.028 (4.131)	0.113
qualitative variables												
Payment card	-22.642 (-2.457)		-22.357 (-2.426)		-22.286 (-2.418)		-47.108 (-2.910)		-46.630 (-2.880)		-46.510 (-2.872)	
Direct question	-34.934 (-3.745)		-34.458 (-3.696)		-34.344 (-3.683)		-54.808 (-3.345)		-54.020 (-3.298)		-53.832 (-3.286)	
Iterative bidding ($2s)	-37.541 (-4.014)		-37.196 (-4.004)		-37.116 (-3.994)		-67.808 (-4.156)		-67.242 (-4.120)		-67.112 (-4.111)	
R^2	.176		.175		.174		.162		.160		.160	
n	184[b]		184b		184[b]		184[b]		184[b]		184[b]	
F	9.53 (0.0001)[b]		9.47 (0.0001)		9.43 (0.0001)		8.63 (0.0001)		8.54 (0.0001)		8.51 (0.0001)	

[a]These estimates are for the combined sample including users and nonusers. It excludes protest bids and outliers detected using the Kuh-Welsch regression diagnostics.

[b]These ● stlmates are for the sample of respondents with usable ranks and reported family income.

The interpretation of these results is somewhat different from the earlier comparison with travel cost estimates. In this case, both methods seek to estimate the same benefit concept. However, they are not independent. Each survey respondent was asked to engage in both activities--one of four types of contingent valuation experiment and a contingent ranking. Thus, these results reflect the consistency in individuals' responses and the potential effects of how the valuation exercise is undertaken (i.e. , requests for bids or ranks). Despite the fairly substantial differences in the means for the two approaches as reported in Table 8-3, these results exhibit remarkable consistency. Once again, the relevant hypotheses are for zero intercept and unitary slope coefficients. Both hypotheses cannot be rejected across all possible variants of the contingent ranking and changes in water quality. Indeed, the numerical estimates of the slope coefficient exhibit rather considerable agreement between the direction of the movements in the two estimates of option price. The estimated coefficients for the question format used are especially interesting. They indicate that the association between the two approaches depends quite importantly on the question format, with the iterative bidding format with a $125 starting. point providing larger estimates than any of the other three formats.

Overall, these findings suggest that even though the models used to derive benefit estimates from the contingent ranking models were somewhat arbitrary (and in some cases inconsistent with a strict interpretation of the relevant theory), the results move closely with the contingent valuation estimates. Indeed, one of the primary sources of divergence between the two arises in the format used with the contingent valuation questions.

8.4 IMPLICATIONS

This chapter has developed comparisons of three methods for estimating the benefits from water quality improvements. Each method has involved a fairly detailed set of assumptions and, in some cases, a complex model. Overall, the results are remarkably consistent across methods for comparable changes in water quality. While this discussion has been devoted to the types of discrepancies between each method's estimates, the consistency in these estimates should be interpreted as offering strong support for the feasibility of performing benefit analyses for water quality changes. The range of variation in estimates across methods is generally less than the variation expected in models seeking to translate the effects of effluent in a water body into the corresponding measures of water quality parameters.

Nonetheless, this conclusion does not imply that there is not room for improvement in benefit estimation methods. In most cases, the indirect methods for benefit measurement, such as the travel cost framework, have been limited by the data availability. While this study's analysis was greatly enhanced by the existence of the Federal Estate Survey, the form of the data nonetheless imposed limitations on the character of the travel cost demand models that could be formulated. Survey approaches do not face the same types of limitations. However, this study's findings do suggest that the question format used is an important factor in the benefit estimates derived from the survey. They also suggest that greater attention to the nature and form of the information provided to survey respondents will be needed if this approach is to seek to develop detailed measures of the components of benefits. The analysis performed for this study had the advantage of a well-defined valuation problem that was easily explained and, according to interviewer feedback after the survey, readily understood by the survey respondents. Many of the most complex environmental valuation problems do not share this characteristic and therefore may not have the same successes reported here.

The specific findings of the comparison indicated that contingent valuation methods may overstate the willingness to pay for water quality improvements. Theory would suggest that ordinary consumer surplus should provide an upper bound for these estimates and this study's findings indicate it does not. Nonetheless, these differences are not substantial and fall within the range of variation of the contingent valuation estimates across the question formatS. For the case of the loss of the use of the area, the association adheres to theoretical anticipations. Indeed, there are reasons to believe that the cost estimates overstate the benefits provided by the area.

Comparison between the contingent ranking and contingent valuation estimates indicate a remarkable degree of consistency. While the mean benefit estimates derived from the contingent ranking framework appear larger than the contingent valuation estimates, there is not a statistically significant displacement between the two. Moreover, the benefit estimates move in close agreement across individuals.

CHAPTER 9

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